THE LADDER OF LIFE

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BOOK VII

SCIENCE READERS

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SCIENCE READERS

BOOK VII

THE LADDER OF LIFE

BY

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SCIENCE READERS

Book I Our Pets

Book II Trailing Our Animal Friends

Book III Baby Animal Zoo

Book IV Animal Life

Book V Makers of Progress

Book VI Early Men of Science

Book VII The Ladder of Life

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PREFACE

The Ladder of Life is the seventh book in a series of science readers for the elementary grades and the junior high school. For many years the authors have been at work on this series, searching for material not too difficult but still interesting and worth while, and testing it in the schools.

No one familiar with the child's interests will deny the strong appeal to him of all animal life. In this series, Book I, *Our Pets,* Book II, *Trailing Our Animal Friends,* Book III, *Baby Animal Zoo,* and Book IV, *Animal Life,* relate entertaining stories about animals. These books are graded in content and vocabulary and have proved highly interesting to children in the first four grades.

Book V of the series, *Makers of Progress,* is largely biographical and relates the stories of great inventors. If our chief objective is to teach children to think, here surely is splendid subject matter to this end.

In Book VI, *Early Men of Science,* the material is also biographical and full of stimulating problems. Here we dip into astronomy and other branches of science through the lives of the great men who blazed the difficult pathways.

Book VII, *The Ladder of Life,* like the earlier books in the series, draws its subject matter from the animal kingdom, but the material is presented from a different point of view. This book gives a general survey of animal life and illustrates the development of animal forms, from the simple to the complex, by stories about individual animals, their struggles, and their problems. A feature of this book which will be welcomed by teachers of junior-high-school pupils is the wholesome, matter-of-fact way in which the processes of reproduction are treated.

Illustrations from *Marvels of the Universe* are reproduced through the courtesy of G. P. Putnam's Sons.

THE AUTHORS

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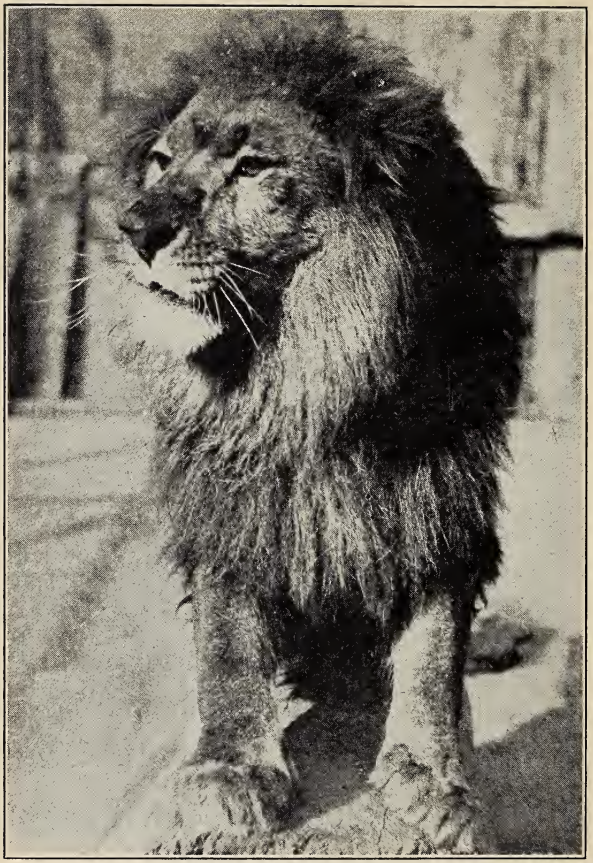
THE LADDER OF LIFE



THE KING OF BEASTS

This is "Numa," whose unusual intelligence and kindliness have made him the star of many great animal motion pictures.

CHAPTER I

THE SIMPLEST ANIMAL IN ALL THE WORLD

TO find the simplest animal in the world I strolled down through the woods until I came to a tiny stream of clear cold water trickling out from a spring in the hillside. Quietly the water went creeping along among the stones and fallen twigs as it started on its long journey to the sea. Here and there along the sides of the little stream were small pools of stagnant water. Black polliwogs now and then left their anchorage along the shores of the pools and wiggled their way to some other harbor near by.

On the floor of these miniature ponds lay dead brown leaves that had fluttered down from the overhanging trees in days gone by. With a long-handled kitchen spoon I scooped up from one of the ponds a few decaying leaves with the ooze and water above them. After carrying it home in a pail and letting it settle quietly overnight, I drew up a thimbleful of water into a medicine dropper and put one drop on a clean piece of glass. Through my microscope I looked into the drop of water, and found it to be alive with living creatures swimming about like tiny fishes or creeping about on the glass at the bottom. It is a queer experience to discover that live animals can be so small that hundreds — and even thousands — of them can find room to move about and make their living inside a single drop of water.

Looking carefully at the tiny animals moving about

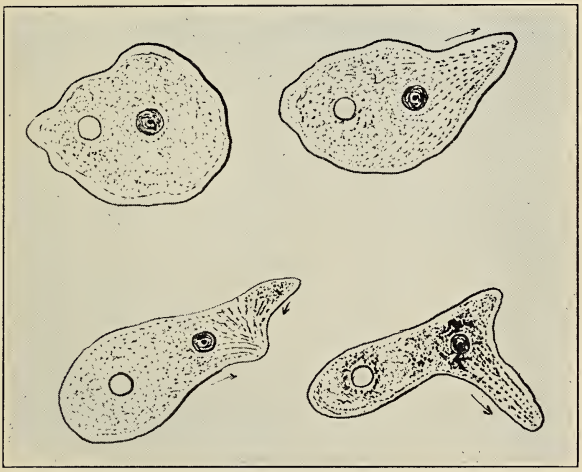
among the specks of dirt on the glass, I finally caught sight of the object of my search. Can that be an animal? It looks like a mere drop of water, or possibly a drop of honey. Watch — it is beginning to move. One side of the drop is bulging out like a finger being extended from a closed fist, though there was no finger there a moment ago. The fingerlike projection is transparent, and I see a tiny stream flowing down through its middle, and little specks floating on the stream like chips of wood sailing along on a river. Now the finger has struck a snag in the form of a pebble, and the stream is turning and flowing off to one side, forming a fork or branch in the finger.

As the fluid body moves back and forth across the glass, I see that the hind end of the soft body shrinks as its contents flow out and pour into the advancing finger. Can you imagine any animal simpler than this — a creature which is nothing but a drop of thick liquid that squeezes itself in any direction it wishes to go? It has no head, no legs, not even a permanent shape, for it is changing every moment that it is moving. This simplest of all animals is called the *ameba,* a name which means "without a shape."

The ameba is so small that a hundred of the biggest ones could line up along one pin. It dwells on the dead leaves and ooze on the bottom of quiet stagnant pools in almost all parts of the earth. If it creeps about so slowly that it takes its lifetime to cross one dead leaf, how do members of its race come to be found in all corners of the globe?

Let us see. When the little pools begin to dry up in summer, and the little ameba is threatened with death

from drouth and the fierce heat of the sun, he eats a lot of food and then draws himself together into a round ball. All over himself he pours or secretes a very tough skin, or shell. Inside this covering he curls up and goes to sleep like a bear in winter time. Soon the pond is quite dried



AMEBA CRAWLING

When at rest, the ameba is contracted into a nearly circular pad. When he wants to go in any particular direction, he squeezes himself on all other sides and allows one side of his soft jelly-like body to bulge out in that direction. He may change his direction by bulging out on some other side and withdrawing the former bulge. The bulges indicate the direction in which he is traveling.

up, and then the west wind picks him up in the form of a dust mote and blows him far away. When he again falls into a quiet pool of stagnant water, he melts off his overcoat and stretches out his hungry fingers just as though

he had not been asleep for months — or maybe years — while he traveled perhaps halfway round the globe.

What does such a queer little fellow eat for his dinner? In the same pool are great numbers of odd plants that are

DIATOMS, THE FOOD OF THE AMEBA
(From *Marvels of the Universe*)

smaller than the amebas and look like blunt needles. Under a powerful microscope each plant is seen to be a drop of jelly inside a tiny box that is decorated all over the outside with pretty lines and figures. These plants are called *diatoms,* a name that means "cut in two." They grow in long chains which later break up into the links that become the separate needlelike plants.

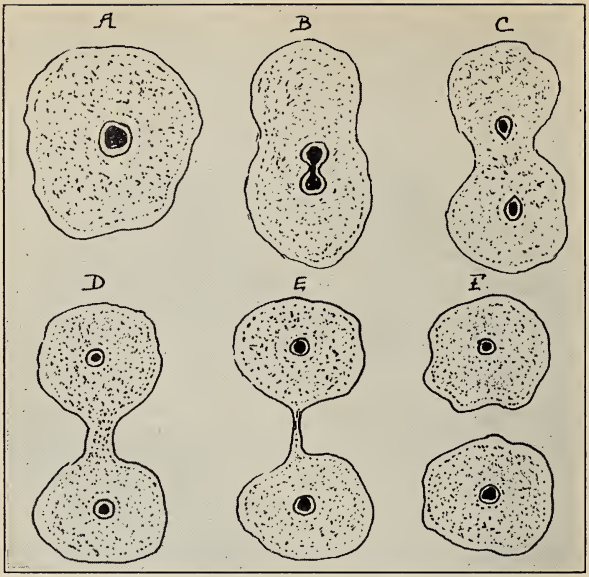
When a hungry ameba finds a bunch of diatoms, which are his natural food, he bulges one side of his soft body up against the little plants so that they sink into his body as a raisin sinks into cake dough. The ameba has no mouth, and can push food into himself at any place on his body. He seems to know what is food and what is not, for he never swallows pebbles, but always slips around or over them.

After the diatom plants are covered over by the jelly-like flesh of the ameba, their soft insides are soaked out through their shells into the ameba's flesh, to serve as nourishment.

Perhaps the strangest thing about this queer creature is the fact that he never seems to die of old age as all other creatures do. If we could patiently watch one particular ameba through his lifetime, which might not be more than a day of our time, we should see him creep about over his dead leaf, gobble up diatoms here and there, and grow bigger and bigger as the hours rolled by. At about the time that we thought he was full-grown, we should see him begin to shrink in the middle, as though he were tightening up his belt. Then he would seem to pull himself apart, just as you pull a piece of taffy in two.

What do you suppose happens? He actually cuts his old big body into two small bodies, and instead of one old animal about to die of old age, there are two newborn babies ready to begin life all over again. The ameba seems to have found the fountain of youth sought so ardently, but in vain, by Ponce de León long ago in Florida.

Out in the oceans there are some tribes of the ameba race that build castles to protect themselves from being

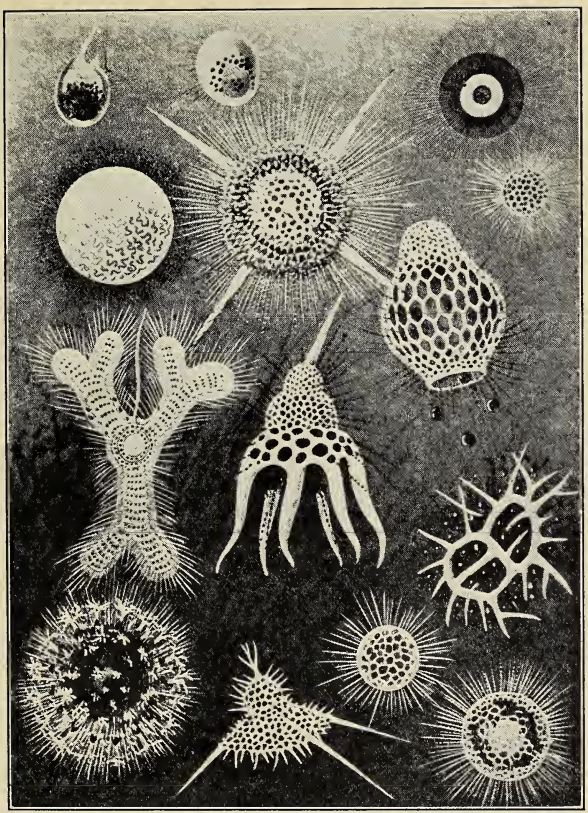


AN AMEBA REPRODUCING

The black dot in the center is the nucleus which carries the hereditary qualities of the parent to the children so that they shall be like their parent. It also controls the dividing of the cell body. It pinches itself into two equal and similar pieces and then pulls the body in two around these two nuclei.

devoured by their enemies. These castles are built of stone and are in the form of globes, usually full of windows or port holes, and sometimes bristling with tiny spears sticking out between and around the windows.

The ameba lives nicely sheltered inside and thrusts out those bulges of his body to serve as mouths when he is



RADIOLARIA

These shells (greatly magnified) were made by relatives of the ameba living in the ocean. The shell is made of sand or flint, and seems like glass. The fine threads are projections of the living body sent out through holes in the shell to capture food.

hungry, or as feet when he wants to move his castle to some more favorable spot. Some of these animals build their castles out of sand grains which they glue together around themselves. Others pour out of their bodies liquid limestone, which hardens into beautiful shells of very regular and artistic design.

Although these shells are extremely small, they occur in countless numbers like the sand grains on the beaches. If we examine with our microscope a piece of chalk from the chalk hills of England, or from the chalk mountains of Spain or Italy, we find it full of these same tiny shells. Geologists tell us that these invisible creatures have built mountains out of their shells, just as the coral polyps have built thousands of miles of coral reefs along the coasts of Australia and Florida. Our beautiful marbles are these same chalks transformed into a crystal form by the great heat of the interior of the earth.

There are still other tribes of these animals that live as parasites inside the living bodies of larger and more complex animals. You are familiar with the parasitic tapeworms and threadworms that live inside the intestines of chickens, dogs, pigs, and human beings. These worms rob those other bodies of their nourishment and interfere with the growth, if not the health, of the animal or person.

The parasitic amebas, while very much smaller than the worms, do much more harm. One sort of these tiny parasites may lodge in the crevices between our teeth and gums. It causes the tissues to decay and form a layer of pus around the teeth which makes them loosen and fall out.

Another kind of ameba lives inside the little red corpus-

cles of the human blood and causes a man to suffer the chills and fever of the disease called malaria. At regular intervals for the rest of his lifetime, unless he kills the parasites with a drug called quinine, he will be afflicted. You should read sometime the thrilling story of how certain medical explorers studied this bad little parasite in the malarial swamps of Italy and finally discovered that the only way the malaria-producing ameba can get into a new human victim is through the bite of one particular kind of mosquito. They found that the mosquito gets the parasite by drinking the blood of a person sick with malaria. The ameba travels gradually from the mosquito's stomach to the glands of its mouth. If a mosquito with these parasites in its glands bites a healthy person, the parasites enter his blood and bore into his corpuscles, so that he becomes ill with malaria.

A very similar kind of parasitic ameba causes that dread disease of the tropics known as yellow fever. During the Spanish-American War in Cuba, some of the officers of the medical corps of the United States Army studied this parasite, even at the risk of great suffering and death, and found that another kind of mosquito was carrying another kind of ameba from yellow-fever victims to our healthy soldiers. More lives were taken by these parasites than by the bullets of the Spaniards. The bravery of the medical soldiers who fought the ameba was just as heroic and praiseworthy as that of the warriors who scaled the heights of San Juan in the face of a deadly hail of bullets.

By draining the swamps and thereby removing the breeding places for the mosquitoes, and by teaching the people to protect themselves from the deadly bite of the

disease-bearing mosquitoes, our army made Havana as free and safe from yellow fever as our northern cities where that fever has never been known. The same procedure was employed to make it possible for the white men to build the wonderful Panama Canal which links together the two oceans and saves the long, tedious journey around South America. The conquering of malaria and yellow fever is one of the notable victories of science.

Questions

1. In what kind of place does the simplest animal live?
2. How may such an invisible creature be handled?
3. Describe the appearance and structure of this animal.
4. How does he move from place to place?
5. What does his name, ameba, mean?
6. How do these tiny creatures get scattered over the earth?
7. What is the ameba's dinner and how does he eat it?
8. How does an ameba keep from growing old?
9. How do the ocean-dwelling amebas protect themselves?
10. How can they get food and move about?
11. How have these ocean animals helped to build the earth?
12. How may one form of ameba injure our teeth?
13. How does another form of ameba cause malaria?
14. Why does a person not get malaria unless a mosquito bites him?
15. How did one kind of ameba kill more soldiers than bullets did?
16. How was Havana safeguarded from yellow fever?
17. How were these facts about mosquitoes and ameba found out?

CHAPTER II

A SPONGE

PHILIP was washing his automobile after an excursion into the mountains on the Fourth of July. Since the car was very dirty, he was using a big soft sponge and a steady stream of water. The boys next door were perched on the fence, watching and asking questions.

"Why do you use a sponge instead of a rag?" asked Bob.

Philip let the water run over the sponge a few moments and then, holding the sponge up where the boys could see, squeezed it hard with both hands.

"Oh, I see," exclaimed Bob; "it holds such a lot of water."

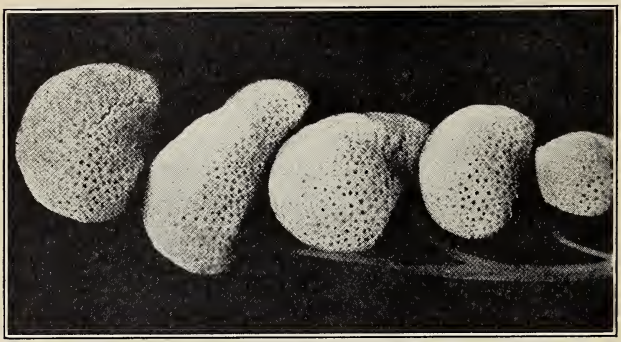
Philip then let the boys feel the sponge, and they found that it was very soft and so flexible that it could be squeezed into a ball the size of an apple. When they let go, it would swell out into a fluffy mass about as big as a muskmelon. Philip then squeezed the sponge dry and showed them how quickly it could suck up water.

"If you boys want to stay here until I finish cleaning this car, I will let you look at a piece of this sponge through my microscope, and then you can see why a sponge behaves in this manner."

The two boys slid off the fence and asked Philip if they could help, so that he would get through more quickly. When the car was clean and under cover, Philip brought out his microscope and mounted a tiny piece of the sponge on a glass slide. Dick took a look and exclaimed, "Why, it's just a mass of fine threads all woven

together!" Bob then had his turn. Philip moved the focusing wheel back and forth and showed how the threads in the sponge run up and down and everywhere, leaving little empty spaces all through the sponge.

Philip explained that these threads are elastic like rubber, and spring back into shape after the sponge has been squeezed together, and that each little space acts like a



SPONGES

The holes are the breathing pores through which the sponge sucks in water containing food and air.

(From *Marvels of the Universe*)

vacuum pump, filling with water when the sponge swells and pouring out the water when the sponge is squeezed. The threads of the sponge are made of a very tough, strong material something like our finger nails.

"How can people make sponges with such tiny threads woven so closely and evenly together?" asked Dick.

"Sponges are not made by man, but are grown by living animals as a skeleton to support their soft bodies, just

as we grow bones inside ourselves. The sponge animals live on the bottom of the warmer parts of the large bodies of water. Many are found in the Mediterranean Sea and near the West Indies. I learned about sponges in my biology course in high school, and I will tell you boys some interesting things about them if you wish.

"Sponges are really animals, though in many ways they seem like plants. They cannot move about, but are fastened to rocks as immovably as plants are to the ground. There are many different shapes, sizes, and kinds, but all are covered with a tough skin that makes them feel like pieces of beef liver. If you were to look at them through a water telescope, so that you could watch them without disturbing them, you would see on each sponge a number of rather large holes that close whenever anything touches the sponge. Each one of these holes is on the top of a kind of mound, or in some sponges at the top of a projection that reminds one of a church steeple.

"The fishermen call these holes 'mouths,' but they are not mouths at all. They are really much more like the openings of smokestacks or chimneys, out of which the smoke pours. If we could only examine one of the chimney pots of the sponge with a good magnifying glass, we should find its sides full of tiny holes like those in a sieve. Biology teachers living near the ocean sometimes dig up a rock with the live sponges growing on it, and put it in a salt-water aquarium in their laboratories in order that the boys and girls may watch the living sponges. If they pour a little ink from a dropper in such a way that it will flow gently down around the sponge, they will see the ink being sucked in from all sides through those very tiny holes and

in a few moments come pouring out of the tops of the chimneys, very much like smoke. Some sponges do not seem to like the taste of ink, for they will give themselves a sudden squeeze that shuts up all the holes and drives out the ink in one violent puff."

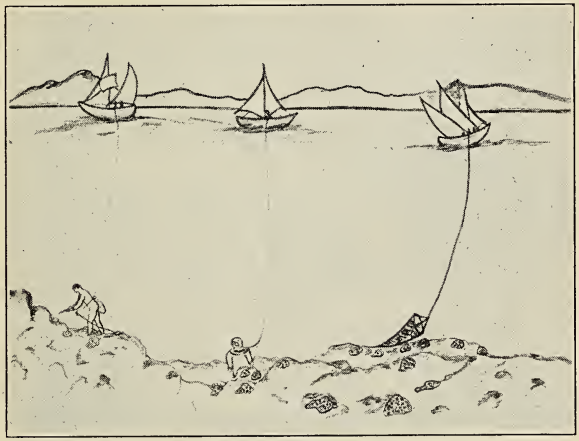
"Why does the sponge drink the ink?" asked both of the boys at once.

"In the first place, the sponge cannot see at all; so he does not know that the ink is there until he has swallowed some of it. In the second place, he is sucking in water all the time, but one cannot see the movement until one puts the ink in the current to make it visible."

"Why does the sponge make these currents in the water?"

"He makes currents in the water to bring him his dinner and to enable him to breathe. His food is the microscopically small animals and plants floating in the ocean. Since he has no mouth, jaws, or stomach, he sucks the tiny creatures in through the little holes in the sides of his chimneylike body. Lining these hundreds of spaces in the sponge skeleton are tiny bits of living flesh that make up the sponge's body and are called cells. Each one of these has a whip something like one of your eyelashes. These whips are always in motion, slowly in one direction and very rapidly in the other, like the lash of a whip that is being cracked. Thousands of these whips are lashing inward in every one of the hundreds of tiny holes on the sides of each of the chimney pots of the sponge. Working together in this way, they keep currents of water flowing in from every side and pouring out at the tops of the chimneys.

"As the food and air are carried along in these tiny streams of water they are taken out by the cells that live along the banks of these streams. Whatever waste materials are to be ejected from the sponge's body are dumped



SPONGE FISHERIES

The boat at the right is dragging a baglike dredge which scrapes the sponges loose and scoops them up. The boat at the left is tending a diver who is cutting off the sponges with his knife and stuffing them into a bag fastened around his shoulders. In the center a man in a diving suit is at work on the ocean bottom. His helper pumps air down to him so that he can remain below for a much longer time than the naked diver.

into these same streams to be swept upward into the big river that pours out of the tops of the chimneys. In this simple way the sponge lives a very lazy, uneventful life."

"Does the sponge have enemies?"

"Not very many. They are pretty tough, with their

leathery skin and rubbery skeleton, and they are glued fast to the solid rocks on the bottom of the ocean. Furthermore, they shrink together whenever they are disturbed, so that all their holes close up tight, and they flatten themselves down upon the rocks. Some sponges have thousands of needles of either limestone or glass sticking out in every direction through their skin and around each of their chimney holes, and are about as pleasant to handle as a porcupine. However, sponges are in constant danger of being buried alive by shifting beds of sand or mud whenever there are great storms stirring the ocean to unusual depths, or whenever floods of river water hurl enormous loads of mud far out over the ocean bottom."

"Where do new sponges come from when the old ones die?"

"Sponges have the power to grow new individuals from pieces of their bodies just as geraniums and some other house plants may be grown from a single branch. Sponges form little buds inside their bodies, and these are carried out by the larger stream of water and left to grow into mature sponges in some other spot in the ocean.

"Sponges also have an animal way of multiplying. The parent sponge lays thousands of tiny eggs which hatch into transparent creatures something like tiny jellyfishes. These babies swim out through the chimney tops and go floating away with the tides and ocean currents until they finally settle down in some far-away spot to set up housekeeping for themselves. Here they send out roots into the crevices of the rocks, build up their cluster of chimneys, and live the same lazy life that their parent did."

"If our sponges are the skeletons of animals living on

the bottom of the ocean, how do they get to the drug store where we buy them?"

"The commoner, less valuable ones, like the grass sponges, live in such shallow places near shore that they

A Sponge Diver

This shows the net bag slung over the boy's shoulders, the knife with which he clips off the sponges growing on the rocks, and the rope by which he will be pulled up into the ship. When he dives he holds the heavy flat stone in his hands. When he reaches the bottom he drops the stone. The rings around his wrist enable him to keep in contact with the rope so that he may be pulled quickly to the surface when he feels he cannot hold his breath much longer.

can be harpooned off the rocks from a rowboat. In order to see them more easily, the fishermen use water telescopes. The simpler telescopes are merely deep pails with glass bottoms. When these are pushed down into the water a

little way, the fisherman can look through the glass bottom and see objects on the bottom of the sea quite clearly.

"The rare and more valuable sponges, like the wool and silk sponges, live at greater depths and farther from shore. These are obtained by trained divers who cut the sponges from their rock beds by means of sharp knives and bring them to the surface in net bags hung from their shoulders. These divers sometimes have fearful struggles under water with ferocious man-eating sharks. In the Mediterranean the Greeks have followed this occupation of sponge fishing for thousands of years, and their boys have been trained from childhood to fit them for diving. They become very skillful in holding their breath and in exploring the ocean bottom with open eyes and sensitive fingers to locate quickly and gather a load of sponges.

"With the invention and perfection of modern air pumps and diving suits, the larger sponge-fishing companies have equipped their divers so that they can remain under water for much longer periods of time and go into much deeper places after the finest sponges.

"When these fishermen return to shore with their day's catch, they throw the sponges into staked pens along the beach, where they are left for days until their flesh has rotted and become soft and slimy. They are then tramped under foot in water to loosen the flesh, and then squeezed and washed by hand until the skeleton is freed from all the decaying body.

"These skeletons are next scattered over the sandy beach in order to change them to a bright yellow color. Their owners then sort them into piles according to their size and quality, and they are sold at auction on cer-

tain days. Crowds of buyers come and bid against one another for the piles of sponges. This is very exciting and is much like the bidding for wheat and corn in the Board of Trade in Chicago.

"As dried sponges are very bulky, they are flattened out like pancakes by being compressed in powerful presses, and are packed into bales for convenience in shipping to all parts of the civilized world. When the druggist gets a bale of sponges, he pulls them apart, for they are stuck together, and soaks them in water till they swell up to their full size. When he gets them thoroughly dry again, he places them in his show case for sale."

Questions

1. How are sponges valuable to man?
2. What part of the sponge animal is our sponge?
3. How are sponges like plants?
4. How do sponges get their food?
5. What sort of happening may result in the death of many sponges?
6. How are new sponges formed?
7. How do baby sponges get scattered into new neighborhoods?
8. Where and how are cheaper sponges obtained?
9. Where and how are the more valuable sponges obtained?
10. How are sponges prepared for the market?

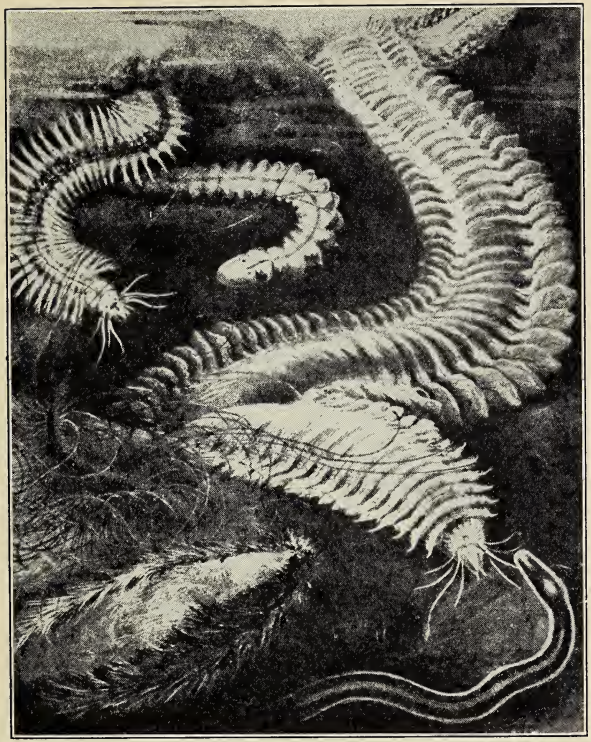
CHAPTER III

ANGLE WORMS

DID you ever go out of doors on a spring morning after a heavy rain and find hundreds of worms? Before men of science tried to find the answers to Nature's puzzles, people took it for granted that these worms rained down from the sky, and so they called them rain worms. Nowadays any boy who wants worms for fish bait knows that they are usually to be found in the soil, and he has noticed that a shower, or even the wetting of the ground by the sprinkler, will drive the worms up to the surface.

Worms are very simple animals, without lungs or gills; so they must breathe through the thin, moist skin of their slender bodies. If they should stay out in the open air and sunshine, their skins would soon dry up and they would suffocate. They are therefore most comfortable when crawling through the moist cool earth, where there is plenty of air for their needs. A heavy shower drives the air out of the little air spaces between the particles of soil, and as there is not enough air in the water for an animal that has no water-breathing gills, the worms hurry up to the surface for air.

Did you ever watch a crawling worm and notice the queer way in which it gets along without any feet? Here is a big fellow just starting off. Let us watch him. See how he stretches out his front end so that it gets long and thin, and how he seems to be feeling this way and that, like a blind man with his cane. After he stretches forward



Sea Worms

These beautiful worms belong to the same group as our common earthworm. They have rows of fanlike swimming paddles which move with a rhythm that suggests the waving of a field of grain when the wind blows. The head is provided with four black eye-spots and many sensitive feelers. The color is changeable with an iridescent sheen like a piece of beautiful silk.

as far as he can reach, his head stands still and the rings in the middle of his body ripple forward one by one. They go like a column of boys moving one step forward as the leader advances one step, each boy in turn stepping into the tracks of the boy ahead. When the middle part of the worm stops wriggling, the tail end slides forward like a sled being dragged along by a rope.

All of these queer motions are produced by two kinds of muscles inside the pencil-shaped body. One set of mus-

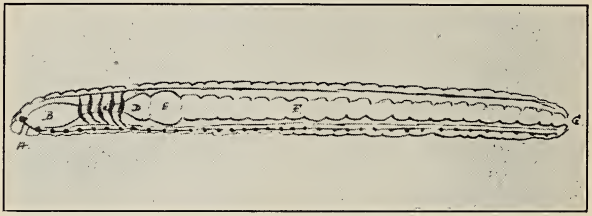


Diagram of an Earthworm

(A) Mouth, (B) Throat, (C) Gullet, (D) Crop, (E) Gizzard, (F) Intestine, (G) Anus. The string of black dots that lie along the under side, one in each ringlike section, is the worm's brains. His blood runs forward in a tube along his back, and backward through a tube beneath his alimentary canal.

cles is like a group of circular rubber bands. They squeeze the worm and make his body get thin and so stretch forward. The other set is like a number of straight rubber bands stretched from end to end of the worm, which pull forward the parts left behind, acting like the rubber in a sling shot.

To keep his moist body from slipping backward as he pushes and pulls himself along, the worm has about a thousand tiny bristles in eight rows along his under side, and

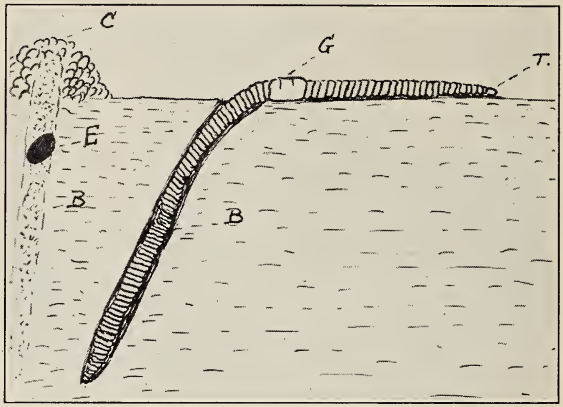
these, catching in the crevices, hold fast to the ground. You can feel these bristles if you let a worm crawl between your fingers. The worm does not have to turn around, for he can crawl backward about as well as forward. He usually travels with the more pointed end forward because that end is more keen of touch and more sensitive to light, and so is a better guide for him.

You might not expect to find brains in such a lowly creature, but, in order to control all those queer motions, each at the right time, the worm has a tiny brain in each of the hundreds of ringlike sections. These brains are all joined together like a string of beads so that they can act at the correct time.

Would you suspect that the worm had a heart? Surely you will be surprised to find that he has eight or ten hearts, and that they look like links of sausage. To see these unusual hearts, just pick up a very small worm, place him between two bits of window glass, and look through him toward a good light. Watch the hearts swell as they fill with red blood, and see them get suddenly smaller as they squeeze and pump the blood down the long tube through which it flows.

On some warm spring evening, take your flashlight and go out on your lawn or into your garden to see if you can surprise the worms in the act of getting their suppers. You must tiptoe very gently or the jarring of your footsteps will startle the timid creatures and they will glide down into their burrows so quickly that you will not catch a glimpse of them. It will be wise not to talk or flash the light off and on, since the worms seem to feel light and sound, though they have neither eyes nor ears.

Let us watch that big brown worm over there between those lettuce plants. See how he stretches out and feels around on all sides. He keeps his tail stuck fast in his burrow so that he will not have to hunt for his home when he wants to slide back into it in a hurry in case of danger.



An Earthworm in Its Burrow

This diagram shows how the worm keeps its tail wedged in the burrow while it explores all around on the surface in search of food. The tip (T) of the head is very sensitive though it has no eyes or ears. The worm digs its burrow by swallowing the dirt and passing it up in a mound (C) on top of the ground. The ringlike girdle (G) forms an egg case that slips off over the head to lie in the burrow (E) until the baby worms hatch.

You can see by the marks on the ground that the worm has been squirming round in all directions.

Now he has found a dead leaf and is taking the end of the stem in his mouth. He is backing down into his burrow and is dragging the leaf after him. We shall not see

him again until he has finished eating that leaf. As he has no teeth with which to chew the leaf, he pours out a juice that softens it into a paste, and then sucks it into his mouth.

One great naturalist made a careful study of the earthworm, keeping his pets in flowerpots on his study table in order that he might observe their actions day and night. He discovered that worms like some kinds of vegetables better than others, and that they eat decaying flesh. He found that they are fond of fat.

Let us scare one of these worms to see what he will do. I will touch him with this twig. See how quickly he jerks himself back into his hole. He acts like a stretched rubber band that has been suddenly released. I am going to grab this big worm and see how strong he is. He certainly pulls, and I can feel his muscles get hard as they try to shorten his body to pull him back into his burrow. I cannot pull him out of his hole very easily, for he has contracted his tail end into a kind of ball which fits tightly into the burrow. It acts like a knot on the end of a rope that a person is trying to pull through a hole in a board. If I pull slowly but steadily, he will get tired after a while; the swelling on his tail will go down, and then I can pull him out. If I jerk him suddenly I am liable to pull his body into two pieces before he lets go his tail hold. Before we go into the house let us stamp with our feet so that we may see all the worms glide quickly and silently into their burrows.

If you are interested in watching the worms, I advise you to get up at daybreak some morning to watch the early bird catch the worm. You will find robins all over

the lawn and garden, running here and there after the worms that tarried too long at their midnight feast. See that robin grab a worm with his beak, brace his legs, and have a regular tug-of-war with the struggling worm. Now the poor worm is getting tired out, for his body is beginning to stretch. When he finally lets go his tail hold, the robin nearly falls over backward.

Occasionally worms get pulled in two by their enemies, or cut in two by the gardener's spade. There have been cases where the broken pieces grew the missing end and made complete worms. Lizards may grow new tails, lobsters may grow new pincher legs, but not many animals can grow new bodies as the worms do.

The regular way for worms to multiply is by laying eggs. Each worm wears a pink girdle or belt around its body near the front end. The skin of this living belt gets loose and peels off, forming a kind of ring. As it slides forward along the body, it passes two little holes through which eggs pour out into the space between this ring and the body. When the ring slips off the front end of the body, it closes up like a leather pouch pulled shut by a puckering string. Thus the ring turns into a little brown leather pouch with the eggs safely stored away inside. If you will look closely in the garden dirt where there are lots of worms, you may be fortunate enough to find some of the worm pouches. They look much like reddish brown kernels of wheat. In a few days the eggs hatch into tiny worms which squeeze their way out of the puckered end and begin their life of burrowing through the earth.

Worms burrow their way through the ground by actually eating a tunnel in the soil. As they dig ahead, the

dirt passes back through their long tubelike bodies and pours out at the tail end. This is a queer process, but it does not seem so foolish when you learn that the worm is able to get most of its food out of this soil as it passes through its body. There is much decaying plant and animal matter in the soil, and this serves as nourishment. The worm has a muscular gizzard much like that of a bird. The food substances are ground fine by the sand and pebbles churning round in the gizzard. As this ground-up food passes back along the intestine, it is changed into a liquid by digestive juices and then is soaked through the walls of the intestine into the blood, to be carried to the working parts of the worm's body.

The worms burrow up to the surface of the ground every night to find and pull down into their burrows the dead leaves and insect bodies that fall there. As they burrow constantly through the soil, they loosen the dirt about the roots of plants and open crevices through which air and water may reach the roots. The waste matter of their bodies forms fertilizer for the plants. If you look in the garden in the morning you will see the little piles of dirt cast up during the night by the worms in burrowing to the surface.

The naturalist who kept worms in flowerpots also studied their work in the fields, and estimated that there were, on the average, about 50,000 worms in the soil of each acre of land, and that these worms, on the average, piled up on the surface every year at least ten tons of dirt. This turning over and stirring up of the soil is just what is accomplished by the farmer in plowing and harrowing his fields in preparation for sowing the seed for his crops.

Thus we may look upon the lowly angle worm as Nature's pioneer farmer and plowman, who has been for many centuries plowing the vast fields of the earth to help grow the annual crops of grass, flowers, and fruits that make our earth a pleasant home for man and all of Nature's creatures.

Questions

1. Why were angle worms once called rain worms?
2. How do worms breathe?
3. Describe how the worm crawls without legs.
4. What prevents the worms from slipping back as they crawl?
5. What is peculiar about the brains of the worm?
6. How can you see the worms eat their suppers?
7. How does a worm eat without any jaws or teeth?
8. How does a worm find out what is going on around him?
9. How does the worm keep from losing his burrow?
10. In what way do worms multiply?
11. How do worms make their tunnels?
12. How are worms Nature's plowmen?

CHAPTER IV

THE SNAIL THAT WALKS ON ONE FOOT

WHEN you go to the zoo and see a stork stand on one foot, you think that a very comical sight indeed. What would you think of an animal that walked only on one foot, and did not hop, at that?

If you would like to see such a creature, go into the garden and peek into shady, moist hiding places under big pieplant leaves or on the under side of cabbage leaves. You are quite likely to find a garden snail asleep in his coiled shell, or you may find his cousin, the garden slug, who has no shell and looks like a slimy worm.

If you live near a pond or sluggish river, you will find plenty of water snails along the shores. Some of them look like coffee beans, some have tapering shells twisted like corkscrews, and some have flat shells coiled inward like a watch spring. You will find it very interesting to watch these creatures. I suggest that you take some of each or any kind home with you for pets and make cages for them. Any fish bowl with green water plants will do nicely for the water snails, and a wooden box covered with wire mosquito screen will do for the land snails or slugs. In this box, place a jar of water with a fresh pieplant or cabbage leaf in it, which you must change daily.

In the daytime you may find the snails all asleep. If so, you had better pay them a visit during the evening. I like to take my flashlight into the garden and watch the snails

and slugs as they creep along the garden paths or climb about over the plants.

Last night I picked a cabbage leaf with four garden snails on it and carried them into my study. In a few moments they began to creep out of their shells into which they had retreated when I disturbed their feast. The soft, greenish-white flesh began to heave and bulge, and then the head unfolded itself. First appeared two flapper lips, next two short rodlike feelers, and finally two long feelers that reminded me of a cow's horns, only these were soft and flexible, and waved this way and that. When I touched one of the feelers, it shrank back into the snail's head.

If you look closely, you can see the snail's eye, a jet-black bead in the knobbed end of each of the long feelers. When you touch this eye, it rolls down inside the feeler like a marble rolling down a tube. You can even see the cord that pulls the eye down the feeler and then pulls the feeler in too, literally proving that the snail crawled into his hole and pulled the hole in after him. In a few moments the feeler comes squeezing out again, and the little eye comes rolling up into its place at the top.

I poked my finger and my pencil at the snail, almost touching his eyes, but he never blinked or showed any sign of having seen me. It is probable that snails do not see very clearly, and that their eyes can merely tell day from night. These long feelers are evidently very sensitive to touch, and as they reach out as far as the width of the shell they tell the snail whether a space is big enough to allow his body to squeeze through.

The snail's short feelers touch the ground in front of

GARDEN SNAILS

These large snails are very destructive to the flowers and vegetables in our gardens. They crawl out of their daytime retreats and spend the nights chewing leaves and blossoms. Their shells are mottled brown and olive color and are not very conspicuous. The spiral shell covers most of the snail's body even when he is in action, and it affords a very good retreat for him when he crawls back inside it.

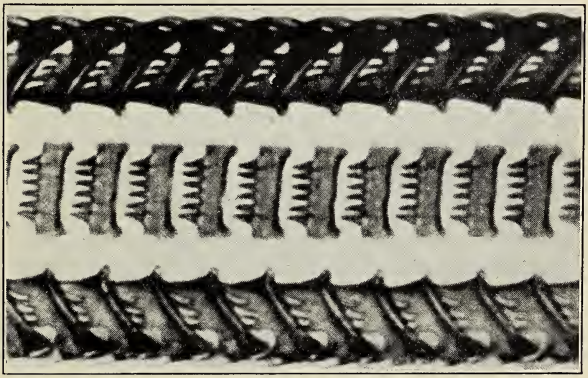
him at every step, and seem to act like the blind man's cane tapping along on the sidewalk. As these little feelers touch everything he walks on, they are believed to possess a keen sense of smell as well as touch in order to help him recognize his proper food.

One of my snails was so little disturbed by being brought into the house that he never left off eating his sauerkraut. He soon ate a hole in the cabbage leaf about as big as a half dollar. I watched this snail nibble around and around the hole in the leaf. I slipped the tip of my finger between the leaf and his mouth, and I could feel his teeth filing away on my skin, but it did not hurt me at all. You can see how a lot of snails and slugs can ruin the vegetables and flowers in the garden. We had one pansy plant in our garden with beautiful blue and white blossoms. For some reason the snails were fond of this one plant and riddled its flowers every night.

All snails and slugs have peculiar teeth and a very odd way of using them. They have thousands of horny, pricklelike teeth set in even rows along the upper side of their ribbonlike tongue. There is a sort of pulley near the front of the mouth; thus they can run their ribbon file rapidly back and forth to rasp off the soft green part of the leaf. Some snails drill holes with just such a file tongue right through the stone shell of an oyster.

Another of my snails was not hungry, or else he was too scared to eat, for he kept wandering all over the table. He would stop and stretch his neck up in the air like a giraffe reaching into a tree top, and then he would feel all around. Not seeming to find what he was looking for, he would crawl a few inches and do the same thing again. It is my opinion that he was searching for a plant or other object to crawl upon, for he evidently did not like the feel of a newspaper. As we hear so much about a snail being slow, I thought I would time his speed. I found that he traveled four inches in one minute, which is a rate of one mile in eleven days.

Later in the evening I placed these four snails on a table under a shade tree in our backyard. The next morning all were off the table. Two were on the lawn, about six feet away, but the other two were nowhere to be found. They must have crossed at least thirty feet of lawn before they hid themselves in the garden. I could not help won-



A Whelk's File

The whelk is a large snail that feeds upon oysters. It has a long ribbonlike tongue covered with three rows of horny plates, each carrying several pointed or curved teeth. Acting like a file, this tongue drills holes through the stony shell of the oyster and rasps away the flesh which is sucked up through the hole into the whelk's mouth.

(From *Marvels of the Universe*)

dering how they knew where the garden was, and why they did not wander round in circles as men do when they are lost on the prairie or in a snowstorm. Sometimes the snails leave a shining trail on the walk and we can see that they often travel in fairly straight lines, as though they realized where they were going.

Now let us see how this queer creature with only one foot crawls along so smoothly and without any apparent effort. His movement reminds one of a sled being pulled over the slippery ice. The glistening silvery trail which he often leaves as he goes — sometimes as a continuous streak, sometimes as a row of footprints — is a slippery slime which oozes out of his body. You can see it trickle along his back between the rice-grain warts on his skin. You can see it pour out behind his mouth, on to his flat sucker foot, and flow backward in tiny ripples. The snail pours out an endless carpet of this sticky slime over every inch of his way; thus he always has a good grip for his one flat foot. He never slips, for he can walk right up the side of the house or a tree. He can even glide, without fear of falling, across a chasm between two leaves far above the ground.

The water snails climb up the wet slippery glass of the aquarium as easily as they glide over the muddy bottom. They even glide upside down under the surface film of the water itself. In order to make all these movements they have many muscles inside their one flat foot, and these cling to the sticky sidewalk and wiggle the body along much as you do your hand when you lay it flat down on the table and let it creep forward by the finger tips and palm squeezing against the table. I have always thought that this queer one-footed locomotion was a most curious way of getting over the earth.

Many animals build themselves homes; often they are very skillfully constructed. The snail grows his house right on his back, makes it bigger as he grows older, repairs any injuries that may occur, carries his house with

him wherever he goes, and crawls inside and barricades the door whenever danger threatens. His house is a spiral shell with the last turn fitted up as a living room. In some families of snails the door opens on the right side of the body; in others it opens on the left side. These snails are said to be right- or left-handed, but the expression does not refer to the use of hands as it does in the case of human beings.

The shell is made of lime, sometimes of a beautiful form called mother-of-pearl. The outside is coated with a tough horn that protects the soft lime or pearl from being corroded by the acids in the water. The horny coat is decorated with some distinctive color design that distinguishes the family to which he belongs. If you could see each snail in his natural home you would find that his color and design match the place where he lives, so as to help make him invisible to his enemies. Doesn't this remind you of the magic cloak in the fairy tales, which made its wearer invisible to human eyes?

This lime or pearl of which the shell is made is secreted — that is, it is poured out in the form of a liquid — by a mantle or skin cloak which covers the snail and lines the inside of the shell. You can easily see the yellowish-green border of this mantle lining the doorway of the shell. If the shell gets cracked in a fall this mantle plasters some lime cement over the broken place. I noticed that one of my four snails had patched up the roof of his house where it had been crushed some time before.

You will probably notice a round hole on the side of the snail, usually the right side, just under the overhanging roof of the doorway. You will notice that it closes once

in a while, and then rather quickly opens again. This is the snail's single nostril and leads into his single lung, which is like a thin paper bag.

The water snail can stay under water only as long as his lungful of air lasts, and then he comes to the surface for air. Sometimes the snails build a rope of slime from the surface to their feeding pasture below and travel up and down this rope when they go for air. You can easily watch all these things if you have some pet snails in your aquarium.

Snails are cold-blooded and very sluggish; so they do not need much air and can get along for a considerable period without any air at all if they go to sleep. During the winter the snails crawl into some sheltered spot and press the lips of their shells tightly against the object that supports them. Then they draw themselves as far back into the shell as possible and pour out a lot of slime to seal up the doorway air-tight. They go into a winter sleep during which they neither eat nor breathe. Men take advantage of this fact to gather and ship edible snails from the vineyards of France to the food markets of the United States.

I once took some snails to school to show my pupils. After we were through studying them I put them in a bucket in a storeroom and forgot all about them until the end of the school year. Then I found them still asleep, sealed up air-tight in their shells.

Snails are peculiar animals in that each one is both a father and a mother. The water snails lay transparent pearllike eggs glued to the leaves or to the glass of the aquarium by a pad of slime. Under the microscope I have

watched the baby snails grow inside the transparent shell. I have seen them roll over and over for exercise; I have seen them push out their heads and eyes; and I have even seen their hearts beat — all before they were hatched.

The land snails and slugs lay white rubbery eggs in bunches of about fifty, which they tuck down in the moist dirt or bury under decaying leaves. My neighbor has a lot of ferns and umbrella plants around his well-shaded porch. I found hundreds of snails as large as my thumb hiding in the shade of these plants. Some of the snails had even climbed up a tree a distance of six feet and hidden away under the decaying leaf mold accumulated in a deep crotch between two limbs. Between the crowded stems of the umbrella plant were scores of snails and many clusters of their snow-white eggs. The eggs are oval-shaped like footballs and look like pearl tapioca. The separate eggs were so rubbery that they bounced like rubber balls when I dropped some of them on the top of the table. I am waiting to see these hatch out regular little snails with complete shells.

Questions

1. Where would you look for snails?
2. How might you keep snails as pets?
3. How does the snail behave when he wakes up from a nap?
4. What peculiar thing happens to his eyes?
5. How much does he seem to see?
6. What is the use of his short feelers?
7. How does the snail eat his food?
8. How fast does the snail travel, and how far did the snails go in one night?

9. What peculiar carpet does a snail have, and why?
10. How does the snail walk with one foot?
11. How does the snail build his house?
12. Why is it decorated?
13. How does the snail breathe?
14. How do water snails travel for their air?
15. Describe the eggs of snails.
16. Where do snails lay their eggs?

CHAPTER

OYSTER SHELLS

"UNCLE TOM, come and tell us about these shells." Uncle Tom was a biology teacher, but it was vacation time for him as well as for his niece and her chum.

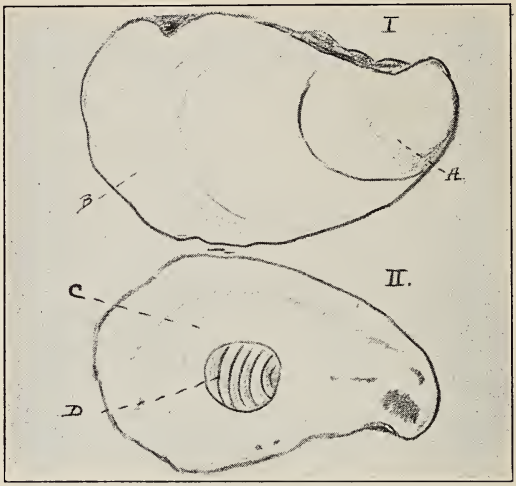
"Indeed I will," he said. "First let me go back to my study to get some specimens of shells which I think will help me to answer your questions."

"You have been playing with oyster shells that used to be oysters' houses, stone castles in which the creatures lived down on the bottom of the ocean. There were so many ferocious enemies prowling about in the ocean that such helpless animals as oysters had to build strong castles to keep out the invaders.

"Here is a bunch of oyster shells stuck fast to a rock just as they were dredged up by the fishermen. You can see that each shell is hollowed out like a tiny bathtub and is cemented firmly to the solid rock. This is only half the castle, for there is another smaller, flatter piece that fits over the top. Over here is a complete shell with the lid in place, and you can see that it fits snugly without even a crack open for some intruder to use in prying the lid off.

"If you could look down into the ocean you would find that the oyster keeps his lid raised just a trifle so that there is an open crack around the wider end of his shell. At the least disturbance the lid is pulled down tight, and it is held so powerfully that you would find it hard work to pry it open even with a strong knife."

"Judging by the oysters I have seen, I do not see how one of these soft things could open and close a door or hold one against a man," said Vera.



AN OYSTER SHELL

The upper part (I) shows the outside of the lower half of an oyster shell. It was fastened to a rock by the part (A), which also shows what was the size of the whole shell when the oyster was a year old. Each year the shell was extended farther and farther out by underlapping layers, as indicated by the lines at (B).
The lower part (II) shows the inside of the upper half which acts as a kind of trapdoor for the oyster which lives in the hollow of the lower half. (C) marks the hollow, and (D) shows the scar made by the muscle that pulls the trapdoor down over the oyster.

Uncle Tom opened a fruit jar and took out an oyster that he had preserved to show his pupils. "Look at this white round thing almost in the middle of the soft mass you think of as an oyster. Feel it."

"Why, it is hard and must be the tougher part we find when we chew an oyster," said Barbara.

"That is a muscle, and a very powerful one. It is not on an arm or leg, as you might expect, but is fastened directly from one shell to the other. It is so attached to these two shells that it has a great leverage which makes it so powerful that few enemies have both the strength and skill to open the oyster's house. But it can be done."

"How does the oyster open the door to his house? Does he push the lid up?" asked Barbara.

"The oyster can open his trapdoor without doing any work. The lid to his house is fastened only at the narrow pointed end, and the hinge is elastic, so that it pulls the lid open the moment the muscle stops pulling it shut."

"What kinds of enemies does the oyster have in the sea that force him to build such a wonderful castle?"

"Some ferocious sea worms with great black jaws; crabs and lobsters with huge pinchers; all sorts of fishes with big mouths. But the oyster outwits all these with his trapdoor castle. There are a few big fishes that have their mouths paved with great flat teeth, and these fishes crush the poor oyster, castle and all, and then spit out the pieces of shell.

"There are two enemies of the oyster that have learned how to play his own game. Here is one of them," said Uncle Tom, handing the girls some prickly five-fingered starfishes.

The girls looked them over, top and bottom. "I do not see how such an animal could open the oyster's trapdoor," said Vera.

"The starfish has two very ingenious ways of getting the best of the oyster. The five arms or rays of the star are

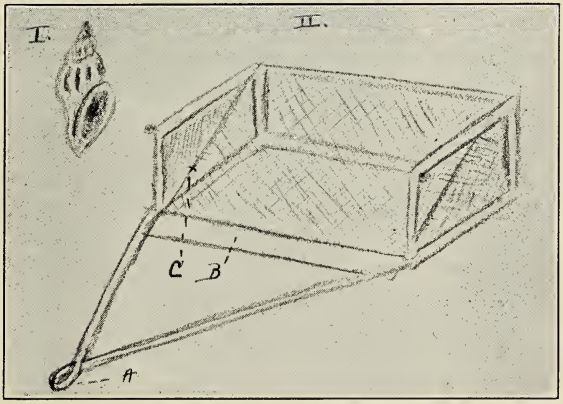
bent like fingers when you bring them all together over any object. There is a deep groove down the inside of each of these ray arms, and there are four rows of tiny holes along the groove. The starfish can stick out through these holes hundreds of slender threadlike feet which are as flexible and elastic as rubber, and are hollow like pieces of macaroni. By squeezing little bulbs at the inner ends of these tube feet, the starfish can force water into them and make them stretch out in any desired direction. When these touch any object they stick fast because there are suction pads on the ends. In this way the five arms of the starfish get a good grip on the two shells of the oyster and then begin to pull in opposite directions. There is a tug-of-war, and the winner is the one who can pull the hardest and longest without getting tired out. Generally the single muscle of the oyster has to yield to the many muscles of the starfish.

"Since the starfish's other trick by which he opens an oyster's shell is connected with his method of eating the oyster, I will explain both habits together. At the base of the five arms you see this tiny hole. It is the mouth, but has no jaws or teeth. When the starfish finds an oyster he crawls on top of the oyster and places his mouth against the edge of the trapdoor just where the oyster opens that little crack under the door.

"The starfish then begins sticking out his lips and keeps pouting them farther and farther out until he has actually turned his stomach inside out through his mouth. He presses this soft rubbery tube against the crack in the oyster's shell and pours out a juice that oozes through it. This juice seems to act like chloroform, for it puts the

oyster to sleep and apparently paralyzes that powerful muscle which is holding the trapdoor shut against the hungry starfish.

"As soon as that muscle loses its strength the spring hinge of the trapdoor raises the lid just as it usually does when



OYSTER DRILL AND DREDGE

The little snail shown at (I) is so destructive to oysters that oystermen find it necessary to make drives occasionally to clean them out of the oyster beds. At (II) is a metal box like a scoop to which a rope is fastened at (A) so that it may be dragged along the ocean bed. The sides and bottom are covered with stout fine-mesh wire netting. The slanting lid (C) is covered with somewhat coarser netting and allows the oysters to slide up the incline and fall back on to the ground while the snails tumble through the netting and collect inside the dredge. The dredge is hauled up on to the deck where the snails are dumped into scalding water. It does not hurt the oysters to be disturbed in this way.

the oyster thinks there is no enemy near by. Probably the starfish uses both of these schemes at the same time. Now that the starfish has succeeded in opening the shell

of the oyster, he slips his protruding stomach in between the opening doors and swallows the helpless oyster. After digesting his dinner the starfish slowly draws his stomach back through his mouth and leaves an empty oyster shell behind him.

"Let me tell you of another enemy of the oyster. It is a snail with a shell that will remind you of the head of the gimlet with which your father bores holes in wood. This snail bores holes, too, right through the stony shell of the oyster. He is called the oyster drill, but he does not use his gimlet shell to drill the hole. All snails have long ribbonlike tongues which they can run forward and backward over a sort of pulley at the front of their mouths. On the upper surface of this ribbon are several rows of very sharp and strong teeth. Some snails have as many as forty thousand teeth on their tongues. This rapidly moving tongue acts like a file. With it the snail can bore a perfectly round hole through the oyster's shell and then scrape off the flesh little by little as he sucks it up through the hole into his mouth and stomach.

"Having lived in the country, you girls are familiar with the things that are raised on farms, but I think you will be surprised to learn that most of the oysters sold in the markets today were raised on oyster farms. You will notice on the map of North America that there are many large irregular bays along the Atlantic coast between Massachusetts and Florida. Most of these bays are ideal locations for oysters; consequently there has grown up a great oyster-farming industry. Each oyster farmer leases from the government a piece of the floor of the bay and drives a stake at each corner of his under-water farm. His boundaries are respected by his neighbors.

"He first clears his farm by raking up any rubbish that would interfere with his farming operations, just as a land farmer clears his land of weeds or timber. Then he scatters, as evenly as possible over the floor of the bay, boat loads of empty oyster shells he gets from the refuse piles around the canneries."

"Do they make new oysters out of old ones, like the man in the Aladdin story who traded new lamps for old?" asked Barbara with a puzzled look on her face.

"Not exactly, but be patient and you will find out what happens. Next the farmer goes away and buys a certain number of bushels of oyster seed. He has figured out how much he will need to plant his oyster beds, and he has to pay from ten cents to one dollar a bushel according to the scarcity of seed that year."

"Do oysters have seeds like corn and beans?" asked Barbara.

"Let us go where the oysterman got his seed and find out all about it. Out in the deeper parts of the bay there are vast beds of wild oysters that settled there long before John Smith fell in love with Pocahontas. The government protects these beds so that they may furnish seed for all the oyster farmers. The oyster, being an animal, does not form seeds like plants, but, like a fish, lays eggs. These eggs are little transparent globes that come out through the crack under the trapdoor like smoke issuing from a chimney. There are so many chances that these eggs, or the baby oysters they become, may be destroyed or lost that these oyster mothers lay each year from sixteen to sixty millions of eggs.

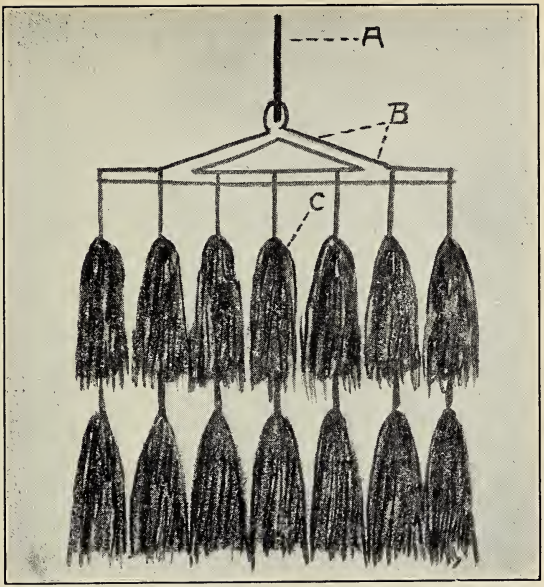
"In a few days these eggs hatch into little swimming bells very much like tiny jellyfishes. They swim and float

about and gradually grow a very thin shell like one of the fairy or jingle shells children delight to find on the seashore, only these are so small that they cannot be seen except through a microscope. The currents and tides carry these baby travelers in toward the shore, where they slowly sink to the bottom as their shells get heavier.

"Some men understand what will happen next; so they prepare traps to catch these little oysters. The Japanese oystermen cut branches from trees and pile them up on the mud flats while the tide is out. These branches resemble shocks of corn in our fields in the fall. In France the men scatter over the shallow bays empty tin cans and broken pieces of tile which they have coated with lime mortar. When the baby oysters come sailing into port they find these convenient landing places; so they settle down on the branches or tins or tiles and proceed to fasten their houses to what they probably suppose are the proper supports for oyster castles. Here they grow rapidly into real oysters like their mothers.

"As soon as these oysters grow to be as big as kernels of corn their captors drag the branches on to the beach or rake up the tin cans and tiles. The little oysters are now stripped from the branches or peeled from the crumbly coating of the tiles and sold to the oyster farmers as seed to plant for a crop of oysters.

"Now let us see how the farmer raises and harvests his oyster crop. He puts his baskets of seed in his rowboat, and while his helper rows him back and forth over the farm he throws the seed in handfuls upon the water. The little oysters sink to the bottom and settle fairly evenly on the old oyster shells previously spread over the farm.



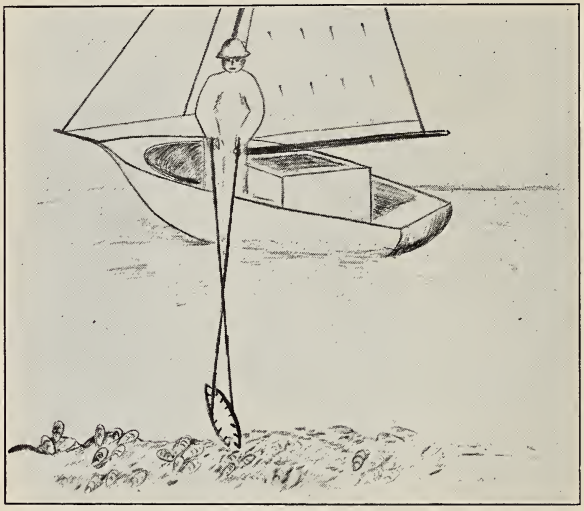
A Starfish Dredge

Starfish devour so many oysters that it is necessary for oystermen to catch and kill as many of them as possible. The dredge consists of an iron bar (B) dragged along the ocean bed by a rope (A). To this bar are fastened several rope mops (C). The prickly-skinned starfish get tangled in the threads of the rope and can be hauled on to the deck, where they are killed by being plunged into scalding water.

"The young oysters immediately fasten their castles to these new supports and go right on with their business of growing. As the corn farmer cultivates his fields to keep the weeds from smothering his growing corn, so the oyster-man tries to keep his beds clear of starfishes and drilling snails. Dragging frazzled rope mops over the young oys-

ters firmly anchored to the bottom, he is able to entangle the crawling starfish and drills and hoist them on to the deck, where they are killed.

"The oyster farmer used to fatten his oysters for mar-



Oyster Fishing

The fisherman holds in his hands the handles of a pair of oyster tongs. These resemble two garden rakes hinged together. He scrapes loose a few oysters, pinches them together with the tongs, and then lifts them up into his boat. This method can be used only in shallow water.

ket in a peculiar way. He raked up his nearly grown oysters and scattered them in more shallow waters near the mouth of a river. The creatures seemed to be thirsty for this fresher water, for they became plump and juicy

and more tender, thus commanding higher prices in the markets. This practice was found to be a very dangerous one, as it was soon discovered that such oysters caused the death of many people from typhoid fever. It is now prohibited by law. As the oysters strained their food out of the water, they could not help swallowing the living germs of disease carried down the river in the sewage from the towns along its banks.

"Oysters are harvested in two ways. The man with a small farm works single-handed from a rowboat, raking up his oysters with a pair of long-handled tongs that are like two rakes hinged together. He rakes together a little pile of oysters and then lifts them into his boat. The men with large farms gather their crops of oysters with the aid of steamboats, dragging queer boxlike dredges over their oyster beds. These dredges are something like the scoops of the steam shovels used in excavating. They scrape the oysters loose from the bottom and dump them automatically on to the deck of the boat.

"There are great canning factories situated along the shores of the bays. Here the oysters are shucked out of their shells, sealed up in tin cans, and shipped all over the country in refrigerator cars."

Questions

1. Describe the oyster-shell castle.
2. How does the oyster keep intruders out of his castle?
3. How does the oyster open and close the trapdoor of his house?
4. What kinds of fishes eat oysters?
5. In what two ways does a starfish open an oyster's shell?

6. In what peculiar way does the starfish eat an oyster?
7. How does the snail drill holes through the oyster's shell?
8. Where is there a great oyster-farming region?
9. What are oyster seeds and how are they obtained?
10. How does the oysterman plant his oysters?
11. How does the farmer keep the animal weeds out of his oyster beds?
12. How were oysters formerly fattened? Why was this practice prohibited?
13. How are oysters harvested on large and small farms?

CHAPTER VI

DEVILS OF THE DEEP SEA

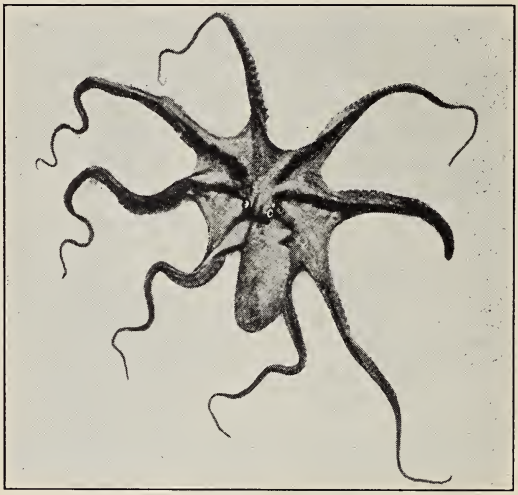
WHILE the sea presents us with animals of graceful form and exquisite color, such as sea anemones, jellyfishes, corals, and fishes, it also produces some of the most hideous and cruel monsters known to the world.

A professional diver working underneath a ship in Los Angeles harbor was horrified to see a huge devilfish, or octopus, creeping toward him over the rocks. Having a diving suit on, he was able to breathe under water long enough to do battle with the monster. After a long, grim struggle he managed to cut through the strangling arms and to plunge his knife into the creature's brain. This hideous beast was on exhibition on Main Street, Los Angeles, for several weeks.

There are two groups of these animals, some of whose members deserve to be called Devils of the Sea. Some of these loathsome and terrifying monsters of the deep are named octopuses and others squids. They belong to the mollusk tribe and are cousins to the oyster and snail.

The octopus and the squid are soft-bodied creatures. In place of the single foot of the clam or snail, they have a set of snakelike arms encircling the head and surrounding the central mouth. They have parrotlike beaks with which they tear their victims to pieces. The boa-constrictor arms, or tentacles, are much longer than the body, and range from a few feet to thirty feet in length in different varieties of these animals. There are eight of these writh-

ing tentacles in the octopus — a name which means "eight-footed" — and ten in the squid and cuttlefish. They are extremely sensitive to touch, and coil instantly around any living object they chance to touch.



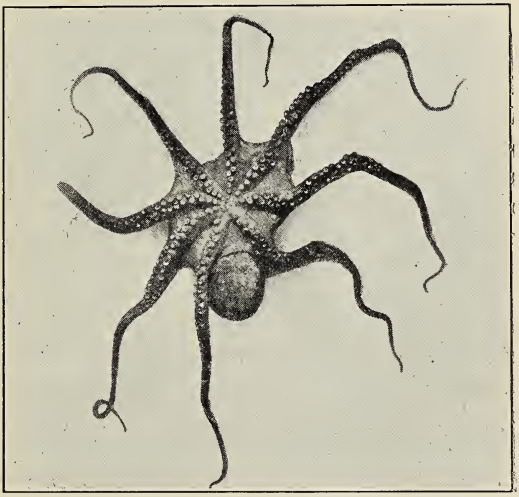
AN OCTOPUS VIEWED FROM ABOVE

This view shows the upper side, or back, of the octopus. Note the sacklike body hanging down between two of the arms, the bulging eyes, the webs between the arms, and some of the suckers where the arms are twisted part way over.

(From *Marvels of the Universe*)

To make matters worse, each of the tentacles is armed with rows of cuplike suckers, sometimes fringed with saw-like teeth, which glue themselves so tightly by air suction to the flesh, and gouge so deeply into it, that it is very diffi-

cult to loosen their grip even after the octopus has been killed and its tentacles have been severed. Because of the double hold of these suckers and the strangling grip of the powerful muscles in the encircling arms, it becomes neces-



AN OCTOPUS ON ITS BACK

This is the lower, or under, side of the octopus. The mouth opens in the center where the eight arms meet, and is equipped with powerful black jaws. The double rows of suckers in each arm are clearly shown and the tapering tendril ends of the tentacles. The sacklike body bulges out between two of the arms.

(From *Marvels of the Universe*)

sary to cut the tentacles off in order to escape from the hideous monster. This is a very difficult task, for the arms are tough and rubbery; nothing but a very sharp

knife can make an impression on them. The danger to a person caught bathing in the ocean lies in the way the monster coils its tentacles around the arms and legs of the victim and pulls him to the bottom, where it is firmly anchored to the rocks below by several of its other tentacles.

The octopus is the most loathsome of the group, if not of all creation, as its body is a shapeless mushy bag of a deathly ashen hue. It has two large black eyes set in the shapeless body just below the base of the snaky arms. It is the only animal without a backbone that has eyes similar in structure to the eyes of animals that have backbones. One observer says that the devilfish's eyes are almost human and that the creatures have a look that makes you feel that they know just what deviltry they are contemplating.

Victor Hugo in his *Toilers of the Sea* portrays this monster in a terribly realistic way, even if his statements are not all accurate. "If terror were the object of its creation, nothing could be imagined more perfect than the devilfish. Its most horrible characteristic is its softness. Its folds strangle; its contact paralyzes. It adheres closely to its prey and cannot be torn away. The spectre lies upon you. The devilfish, horrible, sucks your life blood away. He draws you to him and into himself. While bound down, glued to the ground powerless, you feel yourself gradually emptied into this horrible pouch which is the monster itself."

In describing how his hero was attacked by the octopus, Hugo says: "Some living thing, thin, rough, flat, cold, slimy, had twisted itself around his naked arm, in the dark depths below. Its pressure was like a tightening cord, its

steady persistence like that of a screw. It was impossible to sever or tear away the slimy hands which were twisted tightly around his body and were adhering by a number of points. The compression increased his suffering. He could scarcely breathe."

A naturalist gives another description of the monster: "He does not start out to hunt his prey until the approach of dusk, when he issues forth from his cave like a veritable dragon of the deep and steals silently and swiftly upon his unsuspecting victim. In a moment it is pounced upon and wrapped around by these long, writhing arms, from which there is no escape. The powerful beaklike jaws are buried in the quivering flesh of the victim, and the silent tragedy of the deep is soon ended. With the approach of the dawn the octopus steals, like some dark, evil shadow, back to his grotto to rest and sleep the sleep of repletion."

Mr. Henry Lee, an English naturalist, watched a captive octopus rear her brood. He tells how she chose a cavern between the rocks in the aquarium and built up breastworks out of living oysters. She crouched in her doorway, watching with her big staring eyes every creature that approached her lair. She grew red with anger, raised her hideous head above the breastworks, and reached out her long, snaky arms whenever any animal came near. She poured out a bunch of eggs, estimated at over forty thousand, laid them in a paperlike boat-shaped cradle, and occasionally played a stream of water over them by means of her swimming water tube. He believed that she did that to cleanse them from tiny parasites that try to prey upon the eggs.

At the end of fifty days the eggs hatched into babies about the size of fleas. These rose to the surface of the water and led a free-swimming existence for a while before settling down to the spiderlike life of their kind. These babies resemble very much baby squids, and during the period that they are swimming about on the surface they are gobbled up in great numbers by schools of hungry young fishes. Those that survive this wholesale slaughter sink to the bottom and begin to skulk around in the dark caverns in search of prey just as their ancestors have been doing from time immemorial.

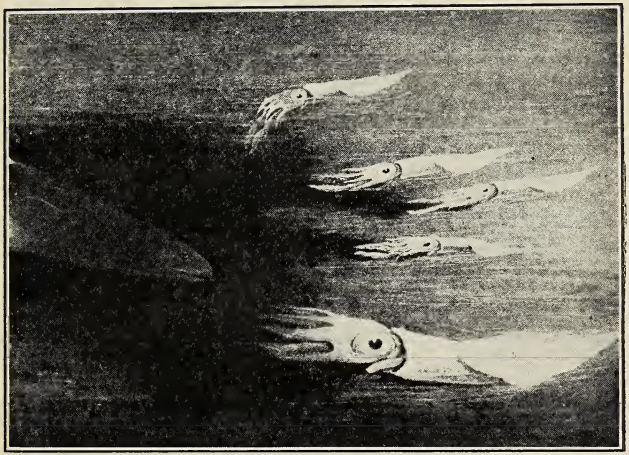
Terrible as these full-grown monsters are, they are preyed upon by equally ferocious fishes like sharks and conger eels, which find their soft flesh so palatable that they are willing to risk a grim fight with an octopus to get the cherished morsel.

There are some varieties of squids that grow to enormous size and become frightful foes if men happen to fall into their clutches out in the open seas. Two of these monsters were once captured off the coast of Newfoundland. Their bodies were nearly twenty feet long and their tentacles about thirty feet, making the whole animal when stretched out nearly fifty feet in length.

The squid differs from the octopus in having a slender torpedo-shaped body with a broad leathery fin on its tail end. It also has two doubly long tentacles in addition to the eight found on the octopus, and these are used as very sensitive feelers. The squid is creamy white in color and has great black staring eyes set on opposite sides of its cylindrical head.

Unlike its crawling, spiderlike cousin, the octopus, the

squid is a very graceful and speedy swimmer, vying with the most agile of the fishes of the ocean. It can swim forward by the gentle wavelike undulations of its kite-shaped tail fin or it can dart backward with the speed of a skyrocket by squirting a stream of water out of its gill



Squids and Eel

This shows a number of squids trying to escape from a ferocious conger eel. Each squid has squirted out of the tube in its neck a cloud of ink called *sepia*. While the eel is groping through this black smoke-screen the squids dart backward by sucking in water under their collars and squirting it out forcibly through the siphon, the breathing and swimming tube. They guide themselves by the flexible tail fin.

(From *Marvels of the Universe*)

chamber through a short flexible tube sticking out from under the collar around its neck. The back-kick of this water as it is driven out hurls the torpedo body backward just as the exploding gunpowder sends the skyrocket

hurtling skyward amid a stream of fire. By turning this tube and bending the edges of its tail fin, the squid can guide itself as well as a fish.

Once upon a time I was studying at a marine biological laboratory on the Atlantic coast, and I recall how I used to watch the schools of baby squids darting about in the water beneath the dock or pier. They might easily have been mistaken for little fishes because of their speed and perfect control. When swimming fast they always swam backward and carried their ten long arms pressed close together and stretched out behind them.

I think I was most interested in the way these creatures changed their color. In the first place, they were so transparent that I had difficulty in following their movements, since their bodies were nearly invisible in the clear ocean water. When they swam over or among gay-colored seaweeds their color changed instantly to the color of the weeds nearest to them. I cannot describe the play of colors of these delicate, graceful creatures as they assumed tints of violet, green, blue, yellow, brown, and red. One observer reports seeing a squid with brilliant red body and bright blue fins.

Underneath the thin transparent skin of the squid lie thousands of tiny flexible sacs filled with liquid pigment. There are four sets of these sacs scattered indiscriminately under the skin, some red, some brown, some yellow, and some blue. Each tiny sac is shaped like a penny and has muscles that enable it to lie flat or stand up on edge. By turning their full face, part face, or edge outward, these sacs make combinations of colors that exactly match the tints of the seaweeds.

The baby squids are such delicious morsels for hungry fishes that they need all their speed and invisibility to escape being devoured.

You have undoubtedly seen pictures of the smoke screens used by warships in their maneuvers in order to hide their movements from the eyes of the enemy. Squids and octopuses were accustomed to using such a device long before man ever invented gunpowder. When attacked, squids puff out a jet of colored fluid, like ink, from a bag under their mantle and shoot it out of their skyrocket tube as they dart backward from their pursuer. The ink spreads out quickly into a black cloud that envelops them in a pall of darkness. Before the water clears so that their pursuer can see them they have hidden themselves down in some dark cavern between the rocks.

The squid and octopus, in spite of their savage manners and appearance, really stand much higher on the ladder of life than do some of the more genteel and better-behaved animals, such as the sponge and the earthworm. The squid and the octopus have much more highly developed sense organs, and their brains, instead of being scattered all over their bodies, as is the case with the earthworm, are formed into a single mass in their heads where they are well protected by a hard covering somewhat like the skulls of higher animals.

Questions

1. How does the octopus family differ from the oyster and snail families?
2. In what three ways is the tentacle of the octopus fitted to hold tight to its victim?

3. Why are the octopus's eyes so terrifying?
4. How does the octopus handle its prey?
5. How large are the giant squids?
6. What are their natural foes?
7. In what two ways does the squid swim?
8. Why does the squid change color?
9. How do the color sacs act in matching the colors of the weeds?
10. How do these animals produce smoke screens?
11. How many eggs does an octopus produce?
12. How does the mother care for the eggs?

CHAPTER VII

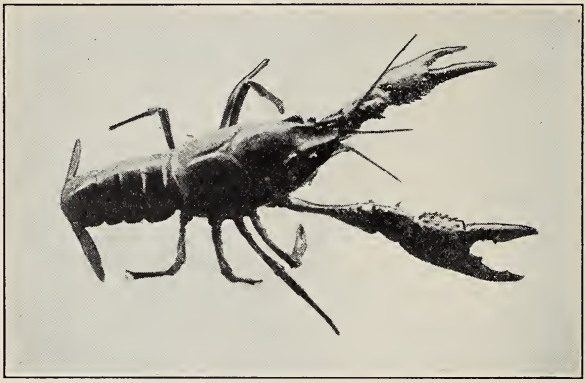
THE FRESH-WATER CRAYFISH

MOST country boys have amused themselves during the long summer vacation days exploring the fields and woods about their homes on the farm or in the small town. There is always something especially alluring about the brooks and creeks that tumble through the woods or wander lazily through the cow pastures. There are often many interesting animals darting about in the pools or hiding along the banks. Have you ever scared up a killdeer or a spotted sandpiper from its nest among the pebbles on the gravelly shores of the stream, or disturbed a muskrat at its dinner on the lily roots, or watched a snake glide into the water and squirm off among the bullrushes in the pond? But probably the thing that interested you most was the awkward, clumsy crayfish stumbling about among the rocks on the bottom of the brook.

The crayfish seems such a queer, impossible kind of creature. It is very much like a lobster, only much smaller, and lives in the fresh water instead of the briny ocean. Its head is not movable like ours; consequently it seems stiff-necked. The head and chest are covered completely by a hard shieldlike shell which sticks forward between the eyes in the form of a short spear. The eyes are on the ends of two rubbery posts and can be pushed out or pulled in, turned this way or that.

The tails of these animals are full of delicious white meat, which is considered as great a delicacy as lobster or crab

meat. The tail is really the abdomen, but is enclosed in a series of shell rings that overlap and bend under because of hinges on the sides. At the end of this tail is a fan composed of five flat plates that can slip sidewise and shut up like a fan. When the animal is scared it flips this fan rapidly underneath and forward. This causes it to swim



A Crayfish

The crayfish looks very much like a lobster, but it lives in fresh water instead of the salty ocean and is much smaller. The body is covered with a hard shell armor.

rapidly backward through the water. You may recall that the squid also swims backward. It must be hard to steer, but the animal does not seem to care where it goes so long as it goes away from the enemy in front of it.

If you have ever wondered how the horse keeps track of his four legs and makes each one move at just the right time, you will surely be puzzled as to how the crayfish manages his ten legs. The legs are long, and their hard

shell covering is jointed into seven sections by hinge joints each of which bends in a different direction. When you see him trying to get somewhere by bending seven joints, you begin to appreciate your ball-and-socket shoulder, your hinged elbow, and your rotating and gliding wrist.

The animal uses only eight legs to walk on, for the front legs are fitted with such big, powerful pinching claws that they are too heavy and clumsy. These may be poor walking legs, but they surely are good pinchers. They grab the prey and hold it securely until the animal has finished devouring his dinner. If you poke the crayfish with a stick he will pinch it so hard that he can be lifted clear out of the water. It is no fun to get your fingers or toes pinched by these claws. They sometimes pinch so hard that the blood flows. The second and third pairs of legs have small pinchers which are used to pick off small pieces of food and carry them to the mouth.

Since the mouth is on the bottom of the head, the animal eats while lying on top of his food. He has two hard crushing jaws and each has a little curved bristly finger that looks like a toothbrush. He probably uses this to feel the food, but it undoubtedly helps to clean the food out from between his toothlike jaws. He is not satisfied with only two jaws; he has six, as well as other appendages which aid them. One pair have flat sharp blades that act like shears in cutting his meat. The last pair carry fans that paddle the small pieces of food in the water into his mouth. All these jaws have fingerlike feelers in the sides; thus he keeps at least twelve tools going at once when he eats.

The crayfish is fond of worms, frogs, and fishes, but he

CRABS

(From *Marvels of the Universe*)

will eat any dead animal. The crayfish has two stomachs. Between them are three stonelike teeth; thus his food gets crushed thoroughly in passing from one stomach to the other. Under the shell on each side of his chest is a cavity or chamber full of white feathery gills that have grown out of the upper ends of his legs. A queer watery blood is pumped by his three-chambered heart through the hollow threads that compose the gills. In order to keep fresh water around these gills inside this chamber, he has two double-headed paddles to keep pumping the water out so that fresh water will run in and bathe the gills. If you squirt some ink down near the base of the hind legs, you will see it sucked in under his shell and come pouring out of the two little channels in front just beneath his eyes. It is a curious sight to see the crayfish smoking like two smokestacks.

You have seen boys who grew so fast that they grew out of their clothes, which became altogether too short for looks or comfort. The crayfish grows pretty fast too, and his clothes fit too tight for comfort; in fact the shell bursts open on his back. This happens only once a year, in the summer time. When the shell gets too tight and splits, the animal wiggles himself loose inside and even shrinks some, too. Then he bends his back and pushes backward out through the crack in his shell. He finally crawls out of his shell and lies exhausted on the bottom of the pond. His empty shell is so complete and unbroken that it looks like another animal. The naked crayfish without any shell is soft and defenseless and a prey to his enemies. Crabs caught in this condition are sold as soft-shelled crabs. For about a week the crayfish keeps hidden while

his skin pours out a sweatlike secretion of liquid lime and horn. This hardens soon and forms a new shell entirely covering and protecting the animal. Thus this animal, in one week of each year, provides himself with a new suit of clothes. This queer shedding of the outer shell is called molting.

Although the crayfish is well protected by his armor and his big pinchers, he likes to hide from his enemies; so he builds tunnels down into the mud under the banks of the stream. Boys amuse themselves by dropping a cord or poking a twig down into the tunnel. The crayfish grabs the cord or twig and is pulled out of his retreat. Some bolder boys run their arm down the tunnel and endure the pinching of their fingers in order to capture the animal.

The female crayfish lays hundreds of eggs that look like little red berries. In order to protect the eggs, the mother glues them on to the hairy paddles under her tail. She carries them with her wherever she goes and bathes them by waving back and forth in the water the paddles to which they are attached. When the eggs hatch, the babies look like their mother, but are no bigger than small peas. These babies cling tight to their mother's paddles and ride around with her. Later they crawl up to get the crumbs from her table while she is eating.

Because they require so much lime to make a new shell every year, these crayfishes abound only in streams running through limestone rocks. Their color is usually green, which makes them more or less invisible among the green water weeds. This color is due to the same kind of iron that is found in the clay which turns red when it is baked to make bricks. When the crayfish dies or is boiled his shell

turns brick red. This is true of the lobster, and because lobsters in the markets are often already boiled, many persons do not know that the live lobster is dark green.

Questions

1. What are some of the pleasures of country boys?
2. What are some of the queer things about the appearance of the crayfish?
3. How can crayfishes swim backward?
4. How can the crayfish bend his legs?
5. What queer kind of feet does the crayfish have?
6. What kind of mouth tools does it have?
7. How does the crayfish get a new suit of clothes?
8. How do boys get crayfishes out of their holes?
9. How do crayfish mothers care for their babies?
10. Why are crayfishes found only in certain regions of the country?

CHAPTER VIII

THE BOTHERSOME FLY

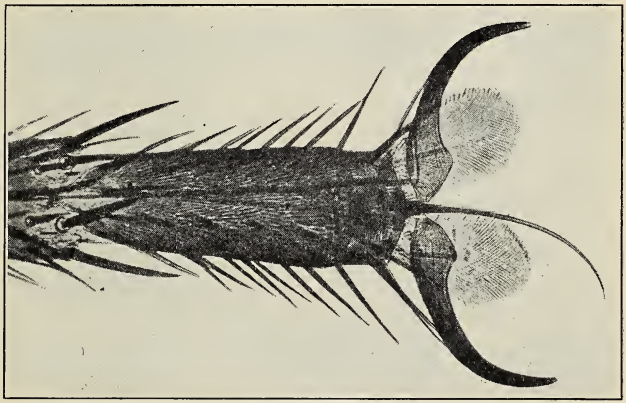
WHAT a nuisance a fly can be when he persists in perching on the end of your nose or buzzing in your ear when you are trying to sleep! Did you ever wonder why the fly can walk so easily on slippery places, and even upside down on the ceiling? Do you know why he is seldom in the spot where you think he is when you slap your hand at him, and how he makes that annoying buzz?

Let us look at the picture of a fly's foot which was photographed through a powerful microscope. We see that the foot has two long curved hooks that cling easily to any rough surface like your clothes. Between these hooks there are two flat pads which are covered with many very small hooked hairs that secrete a sticky stuff like glue. Besides being held fast to smooth slippery things by these sticky hooks, he is also held by the suction caused by squeezing the air out from under these pads when he presses his foot down on a surface. This explains how a fly can walk on the ceiling or climb up a glass windowpane.

Now let us see why he nearly always escapes when we try to swat him. Look at his head and you will see how his big red eyes form two great conning towers filling nearly the whole head. Each big eye is made up of thousands of little bull's-eye lenses pointing out in every direction. Since each of these lenses is a simple eye, he really has many thousands of tiny eyes instead of the big one you think you see. Thus it is practically impossible

to catch him unawares. Besides these powerful compound eyes, the fly has three small simple eyes in the middle of his forehead between the big eyes.

But how does the fly get to a different spot while you think he is still in the same place? If you watch, you will



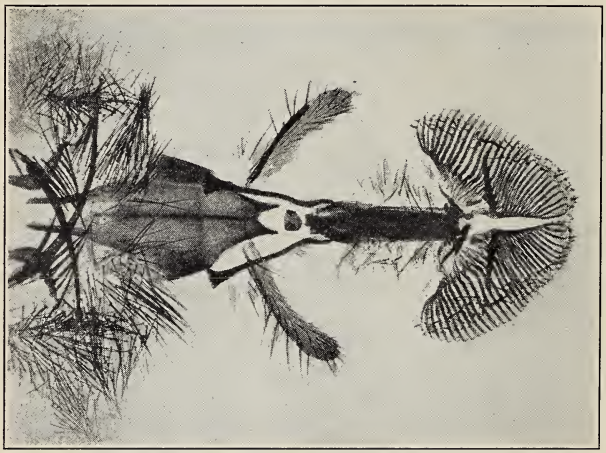
A Fly's Foot

The two large curved hooks are the means by which the fly holds on to rough surfaces. The two oval objects are sticky pads by which the fly clings to smooth surfaces, as when he walks up a pane of glass or upside down on the ceiling. Unfortunately germs get stuck to these pads when the fly walks over filthy matter, and they are transferred to our food when the fly walks over our butter or swims in our milk.

(From *Marvels of the Universe*)

see that he does not jump out of your way as a flea does. He uses his six slender legs for running, not for jumping. He has only two wings, which are not very large and are as thin and transparent as gauze. While he is crawling over your hand these wings are spread over his back but are not folded. If you watch these wings as you

try to swat the fly, you find that your eyes cannot see what happens because it is all over before you can say "Jack Robinson." These wonderful little wings, ready for instant service, can be moved hundreds of times a second, and are able to flip the fly's body out of the way a great



THE FLY'S MOUTH

This picture shows the fly's mouth very greatly magnified. This is the little thing you see the fly unfold and thrust down upon the food. You can see the joint in the middle and the two rods by which it is raised and lowered. The two lobes at the top are covered with rough spiral tubes that file the surface of objects. The moistened food particles are sucked up through these tubes into a large tube that leads into the stomach. The two hairy "fingers" are delicate feelers that examine and test all objects to guide the fly in his eating.

(From *Marvels of the Universe*)

deal faster than you can possibly move your hand. The breeze made by the movement of your hand is strong enough to blow his light body away like a bit of chaff.

You can catch him with a fly swatter because it is open and does not make much breeze. The fly's body is so full of air tubes and air-filled balloons that it does not weigh much more than air itself, and so is very easily wafted about.

You probably have noticed some flies poised in the air like humming birds; then all at once you see them hovering in another spot several feet away. Their wings move so fast, and hurl the fly through the air so rapidly, that your eyes cannot follow them.

Does the fly make his buzzing noise with his mouth as most animals do? If you will catch a fly and hold him by the legs, and later by the wings, you will find that the rapid vibration of the wings acts like a tuning fork and produces part of the annoying noise. The air breathed rapidly through the several tiny breathing holes along the sides of his body makes a shrill snoring sound that completes the buzz.

You will find it interesting to watch a fly eat his dinner. Take a piece of bread spread with syrup or jam and watch him drop down his queer little tongue like an elephant's trunk into its sweetness. He carries his tongue doubled up and folded into a groove in his face when he is not using it. As he lowers his tongue and unfolds it, the lower end opens up into two flaps that spread backward. As he walks over the food, he keeps raising and lowering this trunk, sucking up drops of liquid food. By looking at the picture of his tongue as seen through a powerful microscope you will observe that these flaps are covered with curved ridges which look like coiled springs. These open into very small tubes which lead to his mouth. The open-

ings are so small that the fly cannot eat large particles of solid food. When he wants to eat something solid, like a piece of sugar, he pours a strong digestive fluid out of his mouth. This fluid dissolves the food, which he then sucks up into the tube you can see running through the center of his tongue.

While the fly goes into what we consider to be very filthy places, he is careful to keep his own body clean. Watch how he washes his face and hands and combs his hair every few minutes. See how he cleans his fingers by drawing them through his mouth flaps and how he rubs his hands or feet together to scratch off the dirt that clings to them. The way he twists his head around and around is a comical sight. You wonder if he will snap it off the slender neck by which it is fastened to his body. He even combs his big eyes, which are covered with tiny hairs.

If you want to see something really beautiful, catch one of the green bottle flies and look at him through your magnifying glass. His eyes are like two rubies set in a filigree border of bristling black hairs, and his snow-white face is decorated with two black rodlike feelers set in a groove. The body is shining green with coppery reflections and is spangled with shiny, stiff black hairs. His wings shine with all the changeable tints of a piece of Tiffany glass.

Hold the fly by one wing and you will see the other wing vibrate so fast in his struggles that it will seem as if he had a dozen wings instead of only one. This wing looks like a fan of many ribs spread out full size. Under the wing are two white folds of skin like bits of crumpled tissue paper, and when they lift up occasionally you can

see underneath them a tiny rod tipped with a white ball. This little rod can vibrate so fast that your eye cannot see it until it stops moving. These rods correspond to the second pair of wings found in all other orders of insects except flies. It is believed that they serve as very delicate organs of balance; they are therefore called "balancers." They remind one of the long knobbed pole that tightrope walkers sometimes use.

A Fly's Egg

The fly deposits its slender yellow eggs under a dead body or in a mass of decaying matter.

(From *Marvels of the Universe*)

As you gaze at the wonderful beauty of the green bottle fly you can hardly believe that, only a few days before, this pretty creature was a repulsive maggot squirming among thousands of its kind inside the rotting carcass of a dead rat. I actually saw this, for I took a dead rat caught in a trap in my barn and laid it on top of a box behind the barn. In a few minutes two green bottle flies had discovered the rat and were running over its dead body. When I returned in a little while, I found that the flies had crawled as far under the rat's body as they could and had

already laid a bunch of several hundred tiny yellow eggs in among the hairs of the dead creature. Think of the wonderful instinct that taught those mother flies to find that rat and recognize it as the proper food for their babies, which they never saw and would not have recognized as their own if they had seen them. What taught them to place their eggs only underneath the dead body so that the sun would not cook the delicate bits before they could hatch, and so that the tiny babies would be hidden from sight long enough to dig their way inside the body of their food supply?

With my hand lens I saw that each egg was a yellow, waxy rod, much like a tiny candle. The next morning when I turned the rat over I discovered that the eggs had already hatched and that many tiny gray wormlike maggots were crawling in and out of a hole they had already made through the skin of the rat. The next day the whole inside of the rat was devoured by the squirming thousands of voracious maggots which had already grown many times their size.

I watched some of these maggots under my microscope and saw that they were pointed in front and that the two black hooked jaws were being constantly pushed in and out of their mouths. Their tubelike bodies were made in joints like stove pipe and these slipped in and out as the worms moved. The hind end was blunt and clung to the rat or other object with clasping hooks. They crawled very fast by stretching a tapering jointed head forward, fastening the front end by the hooked jaws, and pulling forward the rest of the body. They prevented themselves from sliding back by gripping the support with their hind claspers.

I saw two tiny yellow beads on the blunt end of the maggot's body and inside his transparent body two branching white lines leading from these beads up each side of his body to the tip of his tapering head. Those yellow beads were his breathing pores and the white lines were his air tubes. The maggot breathes through his tail so that he will not suffocate while he is diving head first into the liquid mass of the decaying body.

The maggots do not bite or chew their food, but pour out a very powerful digestive juice that changes the dead flesh into a liquid which they pump up into their stomachs. In just a few days the thousands of maggots had completely destroyed the dead body, and only a dried-up skin and the bones were left. Since I had placed the rat on a can of earth, I found that the maggots, as soon as they were fully grown, had burrowed down into the earth and lay asleep inside their last maggot skin, which had hardened into an oval brown leather case. Putting a wire screen over the can, I was able about a week later to capture scores of beautiful green bottle flies that had hatched out of those disgusting gray maggots.

If a fly can lay her eggs and hatch out a brood of adult flies like herself in ten days, do you wonder that we have such droves of flies toward the end of the summer? If you enjoy arithmetic, amuse yourself by figuring out how many flies there would be at the end of the summer if the mother fly in the spring laid one hundred eggs. In reality each female probably lays from three to five such batches of eggs. Fortunately all the eggs do not hatch, all the maggots do not live to become flies, and all the daughter flies do not live to lay eggs; otherwise we should

not be able to breathe, because the flies would fill the air. One man estimated that there would be about 6,000,000,000,000 — or six million million — descendants from one fly in one summer.

The swarms of flies really help to make this earth a clean, sweet-smelling place on which to live. You ask how that can possibly be. Perhaps you have not realized that man is the only creature that buries his dead, and that countless animals of all sizes and kinds are dying every year, and that their dead bodies would defile the face of this fair earth if there were not some natural means of disposing of these bodies.

The countless voracious maggot babies of the beautiful flesh flies are, then, a group of undertakers who are given the job of removing the unsightly and ill-smelling bodies of the dead. Some one has said that a fly can devour a horse more quickly than a lion can. When you realize how wonderfully the swarms of flies and their hungry children are fitted to find and destroy dead flesh of all kinds in all places, even the most inaccessible, you understand that there is a real need of even the despised fly.

We must remember, however, that most insects lead a double life, living a part of their lives as one form of animal and the rest of their lives as an entirely different form. They may be, from man's point of view, very useful animals in one form and very troublesome ones in the other. We have seen how the fly maggots are Nature's scavengers. They are only acting on their instinct to destroy all dead flesh when they attack the meat which man is trying to keep for tomorrow's dinner. We shall be obliged to protect our meat foods by screening them from flies until such

time as the human race can work out a feasible substitute for these scavengers.

Now let us go back to the adult flies with their gorgeous clothing and their immaculate personal habits. In following their instinctive search for their own natural food, and for that of their maggot children, they are obliged to walk into very foul places. It happens that these places are also the feeding grounds and workshops of another kind of Nature's scavengers, the bacteria of decay. Sometimes among these beneficial bacteria may be found certain parasitic germs that prey upon living creatures both animal and human. We call these disease germs, and we must protect our lives at any cost from their deadly attacks. Bacteria, both harmful and harmless, are very easily attached to the sticky feet and hairy bodies of the flies, and are carried about by the flies without in any way benefiting them in their work or life.

Even under these circumstances the flies would not do us any harm if it were not for their most unfortunate liking for the things we like to eat. The house flies are very fond of sweets, and so flock into our houses whenever they get a chance. They walk over our food, take a bath in our milk, and even track their dirty feet across a baby's food-smeared lips. In these ways the flies carry from filthy places the germs of such human diseases as diarrhœa, cholera, typhoid fever, and tuberculosis. Consequently, in spite of the excellent scavenger work of the fly maggots, it becomes necessary for the human race to wage relentless war upon the adult fly because he spreads disease.

From what we know of the life history of these insects "it is almost as hopeless to expect to stop the fly menace

by swatting the adult flies as it would be to expect to empty the ocean by dipping out the water." One may keep flies out of his home by screening and by swatting and poisoning the adult flies, but the only way really to get rid of flies is to make it impossible for them to breed and rear their young near human habitations.

As the house flies lay their eggs and raise their maggots mostly in horse manure and human garbage, before we can exterminate the fly it will be necessary to screen stables and keep the manure in fly-tight boxes, and to put garbage in covered metal cans and burn it promptly in incinerators.

Since the flesh flies breed in dead flesh, we know that the bodies of all dead animals must be promptly removed and destroyed, that all refuse from slaughterhouses and fish markets must be kept screened from flies until it can be destroyed, and that the meats in all markets must be kept in refrigerators or in screened cases.

These battles against man's insect foes demand the co-operation of all the people in the country if we hope to win in the grim war for freedom from disease.

Questions

1. How is the fly able to walk upside down on the ceiling?
2. Why is it so difficult to hit a fly with your hand?
3. How does the fly move so quickly?
4. How does the fly make his buzzing noise?
5. How does the fly eat his dinner?
6. How does the fly make his toilet?
7. What helps the fly to keep his balance?

8. How and where do fly babies live?
9. How is the maggot fitted to breathe while feeding?
10. How do the maggots eat?
11. How do maggots make the earth a cleaner place for us to live on?
12. How does the adult fly harm man?
13. How may man get the best of the fly?

CHAPTER IX

BEETLES THAT BURY

A LITTLE goldfinch, weary from its long journey from the tropics where it wintered, with its ordinarily keen eyesight blurred from fatigue, dashed against an unseen wire and fell to the ground a limp mass of pretty feathers. Having fallen by the roadside far from human habitations, it lay there, undiscovered by prowling cats. The next day the little dead bird was visited by four solemn little beetles dressed in black garments whose somberness was relieved by four blotches of red on their wing covers. Could they be mourners come to perform the last rites over the dead bird?

After crawling silently all around and over the bird, the strange little beetles began digging a trench around the place where the bird lay so quietly. They made the dirt fly as they scraped with their sturdy front legs and kicked it behind them with their strong hind legs. Little by little the trench deepened and extended until it reached in an irregular line around the bird. Before I left, the beetles had dug down underneath the bird until they were out of sight and only the flying dirt and rising rampart showed that they were still busy.

The next day when I returned there was a nice little grave with the little goldfinch lying undisturbed in the bottom. Why had the little animals, in no way related to the little bird, come from afar and worked continuously all night long to give the dead bird a decent burial? They

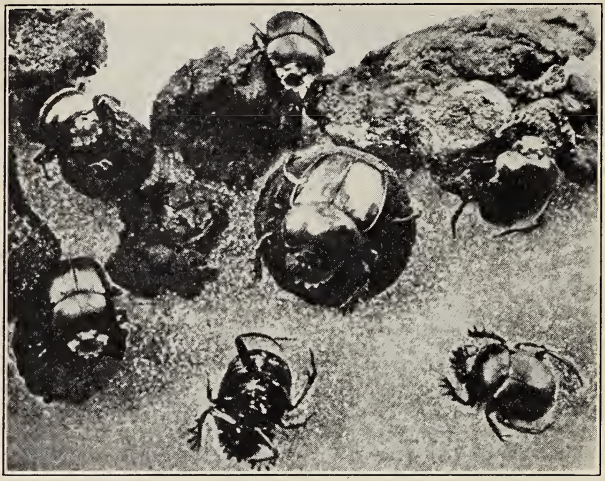
had a purpose of their own even if they did not molest the body. When they had lowered the body to a depth they considered proper, they burrowed under the dead body and carefully stowed among the feathers a bunch of their eggs. Then they filled the grave, covering up the little bird's body so that no other creature should find and devour it. In this wonderful way they protected their unborn children and provided the helpless youngsters with appropriate food in such quantities as would last them until they had passed through their babyhood and were strong enough to battle their way out into the world.

I recall that, as a boy on the farm, I used to see one or two dull-black, round-bodied beetles rolling a ball along the road from the hay field to the barn yard. In those days I did not understand the meaning of this strange and unusual behavior and I supposed the queer little bugs were playing some game as children roll snowballs in winter. I watched their funny antics and laughed to see their mishaps as the bug in front got rolled under the ball, or they both went sprawling when the ball got beyond their control and rolled down a steep incline. I knew that they buried the ball in the soft ground by the side of the beaten path, but I supposed that they were hiding their plaything until the next day.

When I grew up and studied zoölogy I discovered that these funny little tumble bugs were not playing and that the whole performance was a very serious business that demanded all their skill, ingenuity, and patience.

Although these queer bugs and their strange antics have been known to men so long that their pictures are found carved on Egyptian monuments many thousands of years

old, Henri Fabre was the first person to study their actions so thoroughly and accurately that the meaning of their game of ball is now understood. If you read Fabre's book entitled *The Sacred Beetle,* in which he describes his



SACRED SCARABS

Here is a group of beetles busily engaged in securing a portion of cow manure, which is their natural food. Each one is rolling into a ball as much food as he can gather. His bowed legs are fitted to move and carve the mass as they continually turn it.

(From *Marvels of the Universe*)

observations of every step in the life of these beetles, you will agree that "truth is stranger than fiction."

During a period of forty years Fabre studied these beetles and untangled thread after thread of their life story. He invented an artificial house for the scarabs in order that he might watch every detail of their house-

keeping at every season of the year. He enlisted the assistance of a bright shepherd boy who was able to carry on Fabre's observations on the beetles in their native haunts in the pasture lands of France. It was this boy who finally discoverd the scarab's nest and eggs after Fabre had searched for them in vain for years.

Scarabs build their balls out of the droppings of cows and horses. They have a very keen sense of smell and can therefore locate a fresh supply of their food in a very short time. They use the toothed shield in their head as a rake to cut off chunks of dung and to sort out any too coarse fibrous particles. The short two-legged front legs push the material back under the belly to the longer curved hind legs. As soon as the legs have patted the mass into a roundish form, it is picked up and turned between the hind legs, which form the mass into a perfect sphere. Layer after layer is piled on, patted down, and then trimmed by whirling between the legs until the beetle has accumulated a ball of food as big as a walnut, sometimes even as large as an apple. Each beetle has been so busy grabbing all he can pack that he has paid no attention to any one else. Sometimes late arrivals find little left for them and they cast envious eyes upon the nice big ball of food already prepared. Occasionally a big burly rascal will knock over the builder and owner of the ball and proceed to roll the stolen property off to a secluded nook where he begins to devour his booty. Because of this risk of highway robbery, the scarabs have developed the habit of carrying their ball of food away to some quiet spot where they bury it out of sight and then eat it in peace and seclusion.

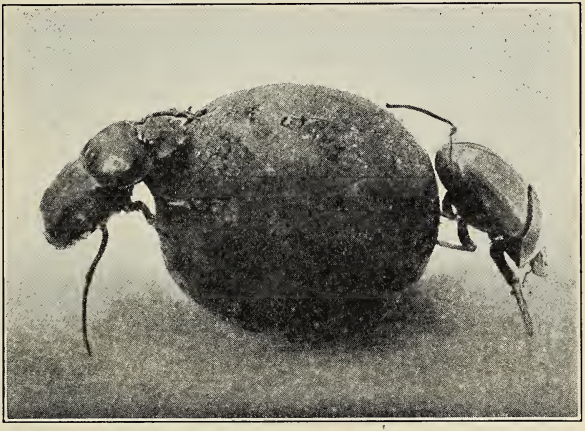
Scarabs make use of the familiar principle that a large load can be moved with the least effort when it can be molded into a spherical form and rolled over and over. Early in his development, man learned this principle and applied it in making primitive carts with large round wheels. We can see the same principle at work today when rollers are employed in the moving of buildings along our streets.

Almost any boy knows that a Ford has most power when backing, as the reverse gear is the most powerful combination. The scarab has been using his similar ability since long before Fords were invented; he moves his ball by standing on his hands behind it and pushing it along by his long hind legs. In order to keep his ball from getting flattened on any one side, he keeps shifting the position of his hind toes on the ball, thus keeping it slowly spinning as it turns forward. Would you have thought of doing that? The only difficulty in this reverse-drive method of locomotion is the beetle's inability to see where he is going. Strange as it may seem, he has very definite ideas as to where he wants to go. He often decides to go across the side of a slope, a procedure which requires wonderful manipulation. Sometimes the ball gets out of control and rushes madly down hill, dragging the luckless beetle with it. Nothing daunted, he picks himself up and laboriously struggles to trundle his round load up the hill and try the same perilous course again.

Not every beetle is allowed to roll his ball peacefully away without molestation. If it is not wrested away by some powerful robber, it may be sneaked away under the pretense of friendly assistance by some lazy beetle who thinks it easier to steal than work. Such a rogue will lend

a hand to help the owner roll his ball away. He gets in front, hoists up his hind legs, and grips hold of the ball while he walks head down, on his hands.

Sometimes this beggar is too lazy even to help pull the ball, and either he climbs up on top and balances himself



A Food Fight

The beetle at the right, pushing the ball backward, is the rightful owner. The other beetle is pretending to help but is really waiting for a chance to steal the ball of food.

(From *Marvels of the Universe*)

for a free ride or he flattens himself out clinging to the ball, even if the ball rolls right over him. When the beetle and his unwelcome partner arrive at such a spot as suits the owner, they stop rolling the ball. The owner now sets busily to work digging a pit under the ball so that he can drop it down out of sight. Since he doesn't trust his supposed helper, he keeps crawling out of his hole to see that the precious ball is safe. Often while the owner is deep

down in the nearly completed hole the rascal-partner harnesses himself to the ball and rolls it away as fast as he can go.

When the beetle finally gets the ball buried out of sight, whether it is his own or stolen property, he digs down into the cellar and sits down to the meal he has worked so hard to acquire. He eats and eats and eats without stopping until every particle is devoured. Sometimes it takes two weeks of steady eating to finish that dinner.

After years of search and experiment, Fabre finally discovered the way the beetle hid and provisioned her egg. Knowing that the ball which the beetles roll along the highway is his own food and never contains an egg, Fabre had his shepherd assistant dig up the tunnels of beetles in the hillsides of the pasture. One day in the fall the boy came to him very much excited over a beautiful little pear-shaped body he had dug out of a tunnel. It was hard and smooth and perfectly even, as though it had been turned out of ebony in a turning lathe.

He chiseled it open and found an egg in a little cavity near the narrow end of the pear. Fabre later found many of these pears, and even succeeded in getting his captive scarabs to build some under his observation. He was surprised to find that the mother beetle was very particular in the selection of food for the provision of this pear storehouse for her baby. She never used the droppings of a horse or cow which was her own food, but used only the richer and finer droppings of a sheep. She arranged this material in layers with the coarser parts on the outside and the finer toward the centre. She even predigested some of the food and left it as a little cup of creamy material sur-

rounding the egg and ready for the baby beetle's first meal.

Space does not permit me to follow Fabre through the whole story of his scarabs. I wish you might read his own account of his work and see the wonderful way in which he traced out step by step the hitherto entirely unknown history of the baby scarab. He tells how he devised artificial egg cases and raised baby beetles in them; how he planned a house with secret peepholes so that he could surprise the mother scarab in the process of constructing the artistic pear cocoon; how he watched the baby seal up the airholes he made in its air-tight case; and how he made many other intensely interesting discoveries.

Nature reveals her secrets to those who patiently, persistently, and honestly seek the truth by observation of her creatures and their behavior.

Questions

1. Who buried the dead bird?
2. How did they dig the grave?
3. What did they hide under the bird before closing the grave?
4. Why did these beetles do all these queer things?
5. What were some of the ingenious ways invented by Fabre to study these beetles?
6. How did the beetle manage to build a round ball?
7. Why did the beetle roll the ball away?
8. How does a beetle sometimes lose a ball?
9. What does the beetle do with the ball at last?
10. What was the purpose of the pear-shaped body?

CHAPTER X

MY ANT HILL

WOULDN'T it be nice to have a motion-picture theater right in your backyard and not have to pay admission? We have just such a theater in our yard and it runs continuous shows from daylight to dark all during the summer vacation when we have the most leisure time to attend the performances. This theater is the outdoor, open-air style like the Greek theaters of ancient days and the stadia and bowls of these modern times. The actors are all midgets and there are hundreds on the stage most of the time. These actors are all community players, for they belong to a community of red ants that have built their nest or ant hill in the path leading from our house to the garden.

I attend several performances a day, for every time I pass their tiny theater I glance at the stage to see what is going on, and often I sit down and follow the players through an act or two. If I find things a little humdrum, I bend down and blow my breath into the door of the theater for the fun of seeing the ants pile out and race around like firemen responding to a fire alarm. They run madly about in all directions, sometimes knocking each other over and sometimes grabbing one of their mates in a rough-and-tumble struggle before they realize that it is a friend and not a foe. Gradually the excitement subsides and the ants resume their interrupted labors.

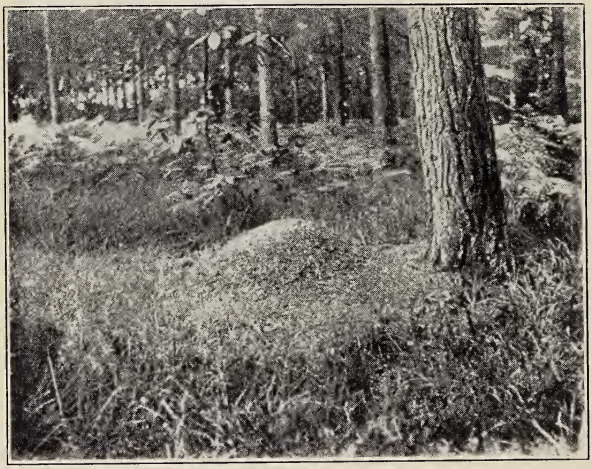
This morning I brought my pets a piece of pot roast and

scattered it in bits on the open ground around the ant hill. As soon as an ant discovered the treasure it raced back toward the nest, touching each passer-by with its jointed feelers that look like a man's arms bent down at the elbows. Apparently ants talk to each other by some kind of sense located in these feelers, for in a few moments many ants were rushing out of the hill and toward these bits of meat. They piled upon the fragments of meat like packs of tiny wolves. Through a magnifying glass I could see each ant run his feelers over the meat and then open wide his powerful black jaws that curve inward like a pair of pinchers. Each ant took hold somewhere on the piece of meat and pulled and shook it like a terrier shaking a rat. After struggling violently without moving the chunk, they all seemed to realize that the piece was too big and too heavy for even their united effort to move. Then each ant attacked the problem in his own way.

One worker managed to find a crack between the meat fibers and pried his claws in until he got a good hold. Then he pulled and twisted until he finally wrenched a piece from the large chunk. Clamping his jaws into the middle of the piece like an iceman picking up a cake of ice with his tongs, he began pushing it slowly ahead of him toward the ant hill. The piece of meat was as big for him as a ten-foot log two feet thick would be for you. He straddled the chunk with his six long legs and stumbled and staggered along with his load. None of the other ants offered to help him as he labored on, over sticks and stones, around larger obstacles, through the crowds of ants pouring out of the nest. Finally he disappeared down the dark tunnel, pushing his burden before him. Not a bite did he take for

himself; not a moment did he hesitate to rest or look for help. Probably not a moment did he tarry for reward as he handed over to the family the results of his labor and turned to rush out to repeat the task.

At the same time that our little hero was accomplishing



A Wood Ant's Nest

These large ants build a mound of sticks and loose soil that rises sometimes to the height of three feet. The nest extends several feet into the ground and consists of rooms and tunnels. The entrances are closed at night and during storms.

(From *Marvels of the Universe*)

his feat, another ant climbed up on top of the big chunk of meat and, finding a weakened spot near the middle, gouged with his powerful jaws as deep as he could; then, moving around as if he were circling a tree trunk, he bit and bit in a circle until he succeeded in cutting the loglike

piece in two. As he victoriously seized hold of one end of his chunk, another ant grabbed hold of the other end. What a tug-of-war followed with each ant jerking and pulling in opposite directions! Their long legs flew back and forth so fast that my eyes could not keep track of them, and the sand flew behind each struggling ant as if driven by the blast of an air pump. Finally the fellow at the end farthest from the home nest seemed to realize that he was making an idiot of himself, for all of a sudden he stopped pulling and began to push with all his might. At once the chunk of meat began to glide over the sand and in a few minutes disappeared down the tunnel in charge of its two staggering porters. All over the field similar struggles were going on, probably no two problems being solved in the same manner.

Scientists who have studied the activities of these wonderful little creatures think that the ants follow no definite plan in their labor, but that each ant workman tackles some part of the job in his own way. If two or more ants find that they are working against each other instead of working together, the more persistent one seems finally to impose his will upon the others. Sometimes it looks as if one had convinced the others that his way is the better way, and then the others give in to him and try to help him work out his plan. This was very evident in the case of the ant who stopped pulling his way and began pushing in the opposite direction.

It is believed that the intelligence of ants is only instinct and not reasoning or thinking, but it is certainly wonderful how these creatures adapt themselves to an infinite variety of circumstances and work out some plan that ac-

complishes the desired end. Man prides himself on the way the human race lives in great communities and accomplishes marvelous deeds through the united action of many fellow citizens, but no nation has ever been able to show such perfect harmony and coöperation, such unselfishness of the individual, and such universal patriotic sacrifice for the community as a community of ants.

An ant seems never to do anything for his own selfish ad-

Wood Ants

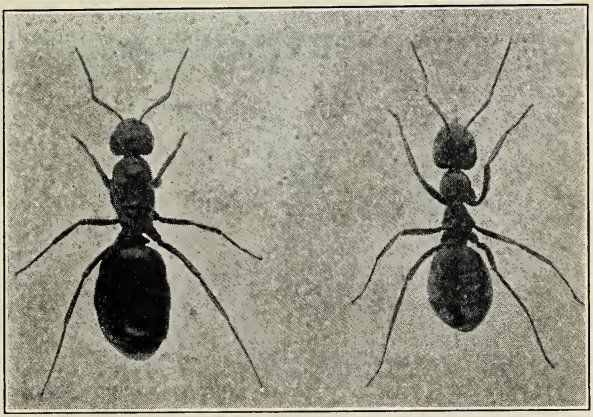
The sexless workers are wingless but the males and females have wings in order that they may mate and establish new colonies at distances away from the old home.
The ant at the left is a male, the one at the right a female.

(From *Marvels of the Universe*)

vantage, and every ant seems ready instantly and unhesitatingly to sacrifice even his life for the good of the tribe. One student of ant life has claimed that the ants have a code of honor which says that no ant shall ever refuse food to another ant of his tribe, and if one should do so he would be instantly killed by his fellow ants.

Ants are insects, which means that they are small six-legged animals with jointed legs and bodies, compound eyes, and usually wings. Ants are unlike most insects because there are three or more forms of individuals in each

family. There are winged males, or fathers, called drones; winged females, or mothers, called queens, who bite off their wings after their wedding flight to a new home; and thousands of wingless workers. These workers have very large heads and much more powerful jaws than have the drones and queens.



Wood Ants

The ant at the right is a regular worker. The one at the left is a worker that has developed the power to lay eggs. This is sometimes done when the colony loses its queen mother.

(From *Marvels of the Universe*)

The ants, bees, and wasps have the most interesting habits of all insects. They live in marvelous community organizations which rival human societies.

My pet ants are the common large red ants. They might well be called miners, for they dig as complicated a set of underground tunnels as would be found in any man-made mine. In this nest that opens on the hard-beaten path

there is only one opening or doorway, which is a hole leading down a sloping tunnel about the size of a lead pencil. The worker ants are about a quarter of an inch long; so only three or four can squeeze through the doorway at one time. There are always some ants inside the entrance, and these seem to touch with their feelers every ant entering the doorway. These are believed to be guards who can recognize every member of the colony, probably by an odor peculiar to the tribe. They certainly pounce upon any intruder. In case an ant dies in the nest, one of the workers — or possibly a guard — seizes the dead body in his jaws and hauls it forth to be cast out beyond the confines of the ant hill. I noticed one ant who grasped the dead ant by the middle and carried him as easily as you would carry a basket. Another seized a dead ant by a feeler or a leg and dragged him along over the ground.

I made a few simple experiments with my ants to test the keenness of the senses which should warn them of the approach of enemies. I walked very close around their hill, but they did not show any signs of noticing my presence. I waved my hand and my hat within a foot of their entrance without creating any disturbance. I should judge that ants see only objects that are close to them. I yelled as loud as I could, and even made a frightful noise by beating a tin pan above their nest, but they seemed to be as deaf as adders. I took a bicycle pump and pumped air over the ants and into the entrance of the nest, but they paid no attention to the breeze. But when I breathed into the entrance the ants came rushing out pell-mell and acted very much disturbed and excited. Probably they were able to smell my breath and so realized that some strange

kind of animal was molesting them. They did not seem to associate me with the disturbance, for they did not attack me, though I was kneeling on the ground only about two feet away from their entrance. When I sprinkled water over their nest they kept right on with their business. Then I poured a cupful of water down their tunnel. A few of the guards struggled up through the water filling the hole, but the ants inside did not seem to be disturbed, for as soon as the water soaked into the soil they came out of the tunnel behaving as though nothing had happened.

I was interested in seeing how far these little creatures wandered away from their home. There was a piece of ground that was bare for about thirty feet around their nest. They were continually crossing this space to disappear under the squash vines in the garden. They must have traveled a distance that would be equivalent to a journey of two miles taken by a human being.

Knowing that ants cannot see very well for any considerable distance, I was surprised when they made these journeys over rough ground that must have obstructed their view of home even if they could see so far. They scampered along up hill and down dale, over stones comparatively as big as houses, and through hollows as deep as a river bed, always in a direct line toward home and never, apparently, in doubt as to the direction they wanted to go. There are times, however, when ants come out of their nest and run aimlessly about. They even seem to play, pulling each other around or wrestling together like a lot of boys at recess time.

Since these ants that were rushing back and forth between their home and the garden seemed to be making

good time, I measured off a circular line ten feet from the entrance and timed a number of ants for that distance. Although the ants were only one-quarter of an inch long, they covered the ten feet in from 20 to 30 seconds by my watch, and it did not seem to make much difference whether they were free or loaded with burdens as big as their own bodies. This means that the ant traveled at the rate of one mile in three hours. When you stride along on your long legs you walk at the rate of about three miles an hour, or only nine times as fast as the ant, who is only about $\frac{1}{3000}$ as big as you are.

The ant's strength is even more marvelous than his speed. I watched one ant yesterday pushing a pebble up out of the tunnel. The pebble was about the size of a small pea, or as big for him as a piano would be for you. The ant grasped the narrow wedge-shaped end of the pebble between his wide-open jaws and, partly lifting and partly shoving, managed all alone to push that enormous burden up quite a steep hill, and finally dumped it over the edge so that it rolled down the slope to the bottom.

I remember reading about a scientist who experimented with some beetles to find out how strong they were. He made a little glass wagon with ball-bearing wheels and hitched it by a tiny wire to a spine on the beetle's shell. He discovered that the insect was able to haul loads 1500 times as heavy as its own body. How many tons do you think a horse weighing half a ton can haul in a wagon on the road? At the best he could probably not pull much more than four times his own weight.

In order to learn something about the inside of an ant's house I looked for another ant hill in the garden. This

house, made by the same kind of red ants, had a dome-shaped top about the size and shape of a wash basin turned upside down. Instead of one opening, it had a number of doors scattered around the base of the dome. These holes were about the size of a pencil and sloped downward beneath the center of the dome. Such an arrangement would probably shed rain well. All day long the ants were hurrying in and out of these entrances, for the red ants love the sunshine and forage only in the daytime. In this they are unlike the black ants that travel about at night. I watched my red ants close their doors every evening at about dusk and open them at about six o'clock every morning. They hauled up pellets of moist dirt from below and plugged up the doorways. One night at about eight o'clock I went out with my flashlight and found one hole partly open, so that one ant at a time could squeeze through. Three ants were drowsily strolling around the dome. I suppose they were the night watchmen making their last rounds to see that all the children were in and that the doors were all closed for the night.

When I dug into this hill I found that the dome came off in one sun-baked crust, and that it was honeycombed with tunnels leading from the doorways to the living rooms deep down in the moist, cool earth. About a foot lower down I dug into a number of spaces hollowed out of the soil. These were the living rooms and nurseries. In these I found clusters of what looked like white rice grains of different sizes. The tiniest ones, no bigger than pinheads, were the ant's eggs.

In other rooms were little wormlike maggots which were the baby ants. The larger oval-shaped grains were the

cocoons or silken cradles holding the ants sleeping in pupal stages. They change during their sleeping into full-grown ants and then bite their way out of the cocoons. If we could have peeped into these rooms without disturbing the ants, we should have seen the workers acting as nurses, feeding the babies, washing them with their tongues as cats do their kittens, or carrying the eggs, babies, or cocoons from one room to another to keep them where the heat and moisture were most favorable.

In order better to watch the activities of the ants, I transferred them to an artificial house made of two tin pans and a pane of glass. When I dug up the ant hill in the garden I dumped dirt, ants, eggs, babies, and cocoons into a pan about twelve inches square and an inch deep. I set this pan within another pan about two inches larger. I poured water into the outer pan to make a moat around the castle so that the ants could not run away from this home. As the ants burrowed deeper and deeper, I kept taking off some of the dirt until I had lowered the top level of the dirt below the rim of the pan and had only about half an inch left. Then I covered all with a pane of glass to form a transparent roof so that I could watch the ants inside their rooms. In order to keep the rooms dark for the ants, I laid a sheet of tin over the glass roof whenever I was not observing them. I fed the ants bread crumbs and small pieces of meat which I dropped in the cracks at the sides between the glass and pan.

Since I was not fortunate enough to find and capture the queen, the colony did not thrive very well or last very long this time. The queen would have gone right on laying eggs which the workers would have raised to form new

ants to keep up the working force of the colony. But in spite of the absence of the queen my ants immediately set to work to build a new hill out of the heap of dirt and to carry their eggs, babies, and cocoons down into the chambers below as fast as they were excavated by others of the ants.

After order and quiet were restored in the ant house, I lifted off the tin cover and watched with a great deal of interest the various activities going on in this improvised glass house. An ant worker would pick up a baby by pinching him right in his middle with her wicked-looking jaws, and then carry him here and there as you would if you were taking a human baby out for an airing. When I poured a little water into one corner of the nest the workers each grabbed a baby, an egg, or a cocoon and hustled into a cavity in the dry corner of the house.

The workers seemed very solicitous about the welfare and comfort of their charges. They gave them frequent baths. They fed the baby ants by licking their mouths. In this way prepared food passed from worker to baby. When the cocoons were ready to hatch, the workers assisted the newborn babies to escape by helping them cut their way out through the end of the cocoon.

Questions

1. How may one enliven the action in an ant hill?
2. How did the first ant manage single-handed to harvest a piece of meat?
3. How did the second ant manage to get some off the big piece?
4. How did the third ant behave?

5. What do scientists think about ants' methods of work?
6. Why are ants called insects and how do they differ from ordinary insects?
7. What simple experiments show the keenness of the senses of ants?
8. How far and how fast do ants travel in getting food?
9. How does an ant compare with man in speed and strength?
10. Describe an ant hill, inside and out.
11. What are the various ricelike bodies found in the nest?
12. How do the workers care for the young of the queen ant?
13. How might you construct an artificial ant hill?

CHAPTER XI

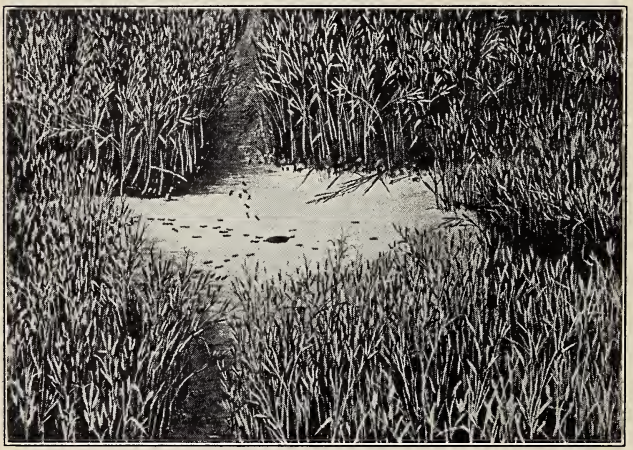
STRANGE DOINGS OF OTHER ANTS

IN the preceding chapter I told you about the things I saw in my own backyard, and you may see the same little drama if you care to watch the ants. There are many strange doings of other kinds of ants that live mostly in far-away places that are just as interesting.

In some parts of Colorado and Texas there are races of ants that are called agricultural ants because they have little farms which they cultivate and on which they raise and harvest crops of ant rice. If you were tramping over the prairies you might run across one of these ant farms. You would find a space of level ground as large as a table, or even as large as a small room, with only one or two kinds of grasses growing on it, while all around would be a forest of weeds. In the center of this farm would be an ant hill from the doorway of which you might see streams of ants hurrying in and out along pathways arranged like the spokes of a wheel. By getting down on your knees you could see that the ants had nipped off close to the ground any weeds that may have tried to sprout on their field. Should any strange animal happen to trespass on the ants' private property, it would soon find out that it had better keep off the grass.

If it happened to be the season of the year when these grasses were getting ripe, you would witness the harvesting of the crop of grain in several ways, according to the kind of ant you were watching. Some merely wait till the

ripe seeds fall to the ground; then they pick them up and carry them down into the storerooms or granaries in their underground house. In other cases the ants climb the stalks of grain and shake or pick the seeds off, letting them fall to the ground for their nest mates to carry away. There are some tribes in this race of ants that climb the



AN ANT FARM

The agricultural ants clear a space about their home and destroy any weeds that start to grow in their field.

(From *Marvels of the Universe*)

stalks, pick off the seeds, and carry them down the stems to the ground and then into the granaries.

These wonderful little creatures do something still more marvelous. They know the secret of keeping these grains, which we call ant rice, in such a way that they do not sprout

or mold. Our farmers do this by keeping their grain in dry, well-aired buildings above ground. How do these ant farmers keep their rice dry and aired down in the moist, dark underground caverns?

Another wonderful thing these ants do is to take out of storage what grains will be needed for a given period and make them sprout, just as poultrymen sprout oats to make tender green food for their hens in winter time. The poultrymen soak the grain in warm water and sprout it in shallow trays set in a rack in a heated room. How does the ant control these necessary conditions down there in his cave?

Chemists tell us that the sprouting of seeds or grains causes a change of the starch in the kernel into a sugar that becomes the sap of the baby plant. Sugar is more pleasing to the taste and much more digestible. Some of the primitive tribes of man have not discovered this secret that these ants know so well.

Another strange kind of ant farmer is the leaf-cutter ant. Its nest is underground in a clearing in the woods. Well-defined trails lead out to the various trees in their neighborhood. The workers march out in armylike columns to some tree whose leaves seem to be just in the right condition to suit their taste and purpose. They spread out over the leaves. Each ant straddles the edge of a leaf and then, with his sharp scissorlike jaws, cuts a circular piece out of it. With a peculiar motion he swings the bit of green leaf up over his shoulder so that it extends vertically along his back where it is held firmly in place, as its lower edge fits into a groove between some spines on his shell covering. Away marches the procession of green

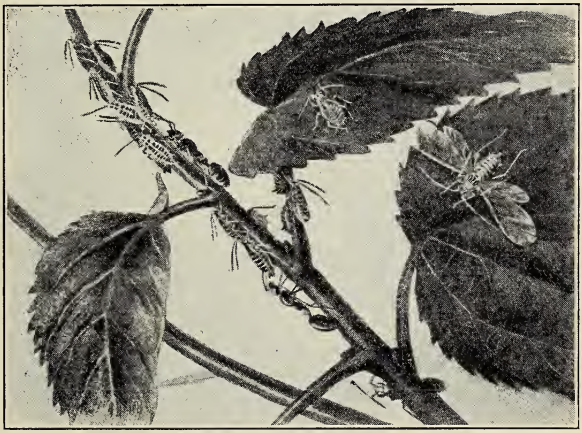
standard bearers, looking like a parade on St. Patrick's Day.

When these ants bearing the leaves reach home, they chew the leaves into a pulp and pack this pulp away in a layer over the floor of one of the caves in their nest. Some ants go to an older bed of this kind and fetch a mouthful of that pulp and spread it over this fresh pulp. That seems a surprising thing to do until you find out that these ants are planting the seeds of mushrooms. Mushrooms were going to seed in the old pulp; thus seeds are sown upon the fresh leaf pulp which is to furnish the food foundation for another bed.

Ants have been seen to take up a bunch of the pulp and wet it with the liquid waste of their bodies and then pack it back in the bed again. Isn't it wonderful that an ant should have learned to use animal wastes as fertilizers for plant growth? You all know that farmers and gardeners enrich the soil for their crops by spreading over the ground manure, which is the waste of animal bodies, and the decayed remains of leaves, straw, and other plants.

When one of the young queens of these mushroom ants starts off alone in the world to begin housekeeping for herself, she carries with her in her mouth a bit of mushroom seed, or spawn, as it is called, and as soon as she has built one chamber of the new nest and has stocked it with fresh leaf pulp, she carefully spreads over it the precious mushroom seed. This grows, spreads rapidly, and finally goes to seed. By taking some of this seed and spreading it on fresh leaf pulp, the ant community can have crops of mushrooms as long as the colony exists. While these facts might seem to imply that ants are intelligent in the same sense that

men are intelligent, you must remember that, as far as we know, all this seeming intelligence is blind instinct — knowledge born in the creature which enables him to perform these intelligent acts without thinking and do them perfectly the first time he tries without ever having been taught or without having seen any one else do



ANT CATTLE

Most ants have learned that plant lice secrete a sweet liquid. By gently stroking a plant louse with her feelers, an ant can get the louse to pour out a drop of this honeydew.

(From *Marvels of the Universe*)

them. It is true that ants seem to have about the most marvelous instincts of any small animals.

Many of the races of ants in all parts of the world are dairymen and keep herds of ant cattle which they guard in their pastures. They milk their cattle several times a day

and even winter them in a special stable down in the underground chambers of the ant hill. Probably you are all familiar with those little green or brown bugs that infest roses, garden vegetables, and fruit trees. We call them plant lice, or aphids, and consider them a nuisance and a pest because they injure or kill our plants. These are the ants' cows, because they occasionally pour out drops of clear honeylike liquid which we call honeydew. Sometimes the plant lice pour out this honey in such quantities that it glistens on the leaves like dewdrops and even drips down from the leaves like rain. The aphids live by sucking the sweet sap of plants through their daggerlike beaks. Some time or other, ants wandering over the plants and trees in their neighborhood must have found some lice that were just then pouring out their honeydew. Being very fond of sweets, they followed these lice much as a child follows the cook who has just given him a cookie. However it may have happened, we find today that the ants and the plant lice live very happily together. The ant cows give up their milk of honeydew whenever an ant pats them on the back with his long, flexible feelers. The ants leave some of their number on guard all day to drive away or kill any beetles, flies, or wasps that might attack the lice in their pastures on the leaves. I have seen photographs of structures built on the leaves by ants to serve as barriers or barns to keep out these enemies that try to gobble up the ant cows.

Instances have been recorded of ants carrying their cattle from a dried-up or dead leaf to a fresh leaf. Several species of ants are known to carry the eggs of their cattle down into the underground chambers of their own dwellings in

the fall and hatch them out in these subterranean stables in the spring. Then, when the weather is warm, they carry the newly born cows up to the right kind of plant for the summer. Ants may do farm and garden crops a great deal of harm by spreading the lice over many plants. There are tribes of aphids living on the roots of corn and strawberry plants that depend upon their ant dairymen to carry them from one plant to another.

In some parts of the world there are ants that have a peculiar way of storing the large amounts of honeydew they collect during the time when the cows, owing to the abundance of tender foliage, are giving a generous flow. In order to carry home bigger loads of honey, these ants have one of the compartments of their stomachs enlarged. Stranger still is the fact that some of the workers hang themselves on the walls or ceilings of the storerooms and receive the honey brought in by the milkmaids, who pump the honey out of their own stomachs into the mouths of these living honey jars. As these honey-holding ants swallow more and more honey, their stomachs swell bigger and bigger, until the ants look like balloons with a tiny ant head and legs sticking to one side.

In rows like jelly glasses on your mother's pantry shelf, these living honey jars hang there in the cupboard until a shortage of food out of doors sends hungry ants to draw upon their hoarded-up preserves. When a hungry ant climbs up and pats the honey ant with its gentle feelers, the honey ant promptly disgorges a drop of honey for the hungry ant, who licks it off her lips and hurries away to feed the queen, the babies, or perhaps some guard who cannot leave his post of duty. Little by little the honey is

doled out in careful rations, for no ant ever seems to be a glutton. When the stored-up honey is all used up, the hanging ants are found to have become reduced to normal size, and they get down and stretch their legs, which must be very stiff after hanging in one position for weeks at a time.

Sometimes it seems necessary to move these honey ants on account of changes in temperature or moisture. Then they have a regular Humpty Dumpty performance, for it takes "all the King's horses and all the King's men" to lift Humpty up again. Several workers will grasp the heavy balloon honey ant by her legs, and then pull and push until they finally succeed in hoisting her up into a higher tunnel. I wonder if they ever roll her along to the next storeroom as we would roll a barrel.

One scientist tells of watching what he at first supposed was a holdup of a honey-laden ant returning from milking a cow in the pasture. He saw two ants jump out in front of this lone ant just as it was about to enter the doorway of its home. The two robbers stood up on their hind legs and held up their front legs as much as to say, "Hands up! Honey or your life!" The honey-laden ant immediately threw up both of its front legs. Then the two robbers thrust their mouths into the face of their victim. After they had drunk their fill of honey, the bold bandits scurried away. It surely looked like a real robbery, didn't it?

After careful study and repeated observations this scientist finally decided that these were workers of the same colony who were assigned to other tasks than gathering honey. It was their lunch time and they did not have time to forage a meal for themselves; so they simply

A Congress of Ants

These ants are holding a meeting. It is believed that the ants in the center are more important members, perhaps the leaders. Those around the outside of the group are soldiers acting as sentinels.

(From *Marvels of the Universe*)

stopped the food gatherer and in their funny ant fashion convinced her that they were entitled to a dinner.

It will probably surprise you to learn that there are tribes of very warlike ants that wage war on other tribes. They have regular pitched battles leaving thousands of mangled dead and writhing wounded on the battlefield, and the conquerors carry off as captives the children of the vanquished ants. These ants have soldiers who are big, burly fellows with large heads and terrible jaws. There are officers that travel along the sides of the marching columns of privates and seem to direct these soldiers. Before making a raid on the enemy, they send out scouts who seem to get certain information and report it back to their superior officers. Then the whole army gets into motion and marches in well-defined columns toward the opposing camp.

These ants are carnivorous, or flesh-eating. They eagerly devour other insects. Probably the purpose of these wars is to secure food, for it must take a great deal to nourish the thousands — if not millions — of ants in one of these colonies. The eggs and babies are delicate morsels of food and are evidently relished by the ants.

When the victorious ants are successful in stealing more eggs and babies than they can eat, they attend to them as to their own similar young. When these captive children hatch out in their prison home, they do not know the difference and they assume the same duties that they would have had in their own home. In this way the conquered ants become slaves to their captors or masters. Some tribes of ants have so developed this system of acquiring slaves that they depend entirely upon their slaves for all

A White Ant's House

This species of white ant does not burrow in wood, but lives on grass and builds a huge castle out of clay. These castles are sometimes over a dozen feet tall and strong enough to bear the weight of a man. Underground tunnels lead out into the pasture.

(From *Marvels of the Universe*)

work except laying eggs and waging war. The slaves seem to be as fond of their masters as though they were their own kin. One observer claims that the slaves appear to be joyful when their masters return from war with many spoils and disconsolate when they come home empty-handed. You may laugh at such an idea, but it is easy to see that ants are very demonstrative, that they get

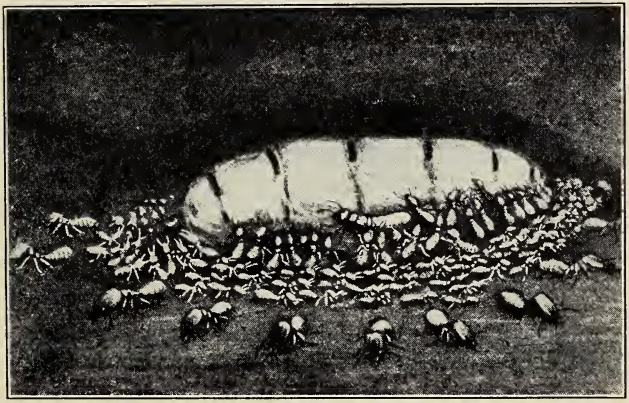
very much excited, and that they seem to express much emotion and perhaps very definite information with their ever-waving feelers.

One student of ant life found two tribes of ants that show a peculiar phase of this slave business. When it comes time for the new young queen to leave the old homestead to start a home of her own, she hunts around for one of the slave tribes. If she finds a colony that happens to be without a queen, she walks in and declares herself queen. Sometimes the queenless colony is so overjoyed to get a queen that it welcomes this one even though she is of a different race. An ant community is doomed to die out if it cannot get a queen to supply it with eggs which will hatch into new ants.

This colony does not seem to realize that all the eggs of the adopted queen will become ants of the master race and that they themselves will become slaves in their own home. As these slaves cannot reproduce their own kind of ants, the colony slowly changes into a tribe of masters who gradually are compelled to do their own labor when their slaves die of old age.

One scientist made some experiments in which he transferred a part of a colony of the slave ants with their babies and cocoons to an artificial glass house. After they were settled in their new home, he introduced a young queen from a master colony. She was quite dictatorial and tried to boss the slaves. These other ants had not been slaves, and they seemed to resent the arrogance of this usurper. There was a fight and the slaves tried to throw the queen out of the hill, but she fought like a fury, killing several of her attackers and stealing a bunch of the slaves' cocoons.

Other slave ants made an attack upon the queen and managed to get back some of their stolen children. The battle waged fiercely for hours, with the final outcome that the fighting queen killed every one of the slave adults and captured all their children. Then she quieted down and became a very devoted mother to all these slave orphans,



A Queen of the White Ants

The queen is the egg-laying mother of the colony and lays about 80,000 eggs a day to keep up the population of the colony. During the egg-laying period she must be fed and tended by nurses. A stream of workers carry her eggs away to the nurseries.

(From *Marvels of the Universe*)

who became her loyal attendants or slaves. She began laying eggs, which, of course, hatched out into ants like herself, but the slaves tended them faithfully. In time the slaves all died of old age and left a colony of only master ants.

We have seen that ants live in great communities with

an organization somewhat similar to that of the human race. They have farms and dairies of honey cows; they have armies of soldiers and officers and wage war much as men do; and they have slaves, just as primitive people used to have in olden times. Perhaps now you will be ready to believe that ants have pets in their homes, like our dogs and cats, that they have beggars on their doorsteps and robbers in their dark alleys, and that they even harbor tiny creatures, like our mice, in holes and burrows in the walls of their ant hill.

All these welcome or unwelcome guests are insects of various kinds. The mice are very tiny creatures that live in the walls of the ants' home. These little insects sneak into the tunnels and storerooms of their hosts, steal food and even eggs and babies, and then scamper into their own tunnels, which are too small for their pursuers to enter.

The beggars are the queer white insects common in our own homes under the name of silverfish or slither bugs. In our homes these bugs do damage similar to that done by moths in clothes. In the ant houses one of these silverfishes sidles up to a worker ant, pats it with its feelers, and tries to wheedle its way into the good graces of the worker in the hope of getting a drink of honey. One man saw a silverfish sneak up close to a worker about to feed a baby ant. Just as the worker nurse squeezed out a drop of honey for the baby to lick off her lips, the silverfish stuck her mouth in between and gulped down the honey and then ran away as fast as she could scamper. Sometimes the ants chase these beggars and give them a good beating, even killing them occasionally.

Some of the little pet insects follow their masters around

and climb up on their backs to comb their hair and wash their faces. In some cases these tiny guests have something on their bodies like either the honey dew of the ants' cows or some perfume that their ant hosts enjoy. Since ants have a very keen sense of smell by which they recognize friend or foe, why may they not delight in perfumes and so welcome any little beggar that can provide them with such a treat?

Questions

1. Where can you find more about these strange ants?
2. How do the agricultural ants carry on their farming operations?
3. How do the leaf-cutter ants carry home the leaf fodder?
4. How do they manage their mushroom gardens?
5. How does a new queen start her mushroom garden in her new home?
6. What can you tell about ant cows?
7. In what different ways do the ants take care of these cows?
8. How do the honey ants keep surplus honey for times of food scarcity?
9. Describe the "holdup".
10. In what ways do soldier ants act like human armies?
11. What is the real purpose of ant wars?
12. How did ant slavery arise?
13. How must the supply of ant slaves be maintained?
14. How does the solitary queen start a slave colony?
15. How was this done artificially as an experiment?
16. Explain the relation of some of the guests to their ant hosts.

CHAPTER XII

A SWARM OF BEES

ONE beautiful sunshiny day in May as I was strolling through the garden, I noticed that one of the limbs of our plum tree was hanging down to the ground under the weight of a great bunch of bees. Going closer, I could see that the bees were hanging on to each other and were buzzing in a contented sort of way. Hurrying to the house, I got an empty hive box and a bed sheet and brought them to the plum tree. Spreading the sheet on the ground under the cluster of bees, and placing the box on the sheet, I gave the limb a hard shake. Down fell the bunch of bees in a squirming mass, but not one of them attempted to sting me for dumping them down so rudely.

Then I sat down in front of the sheet and watched to see what would happen. The bees were crawling very excitedly in every direction. Some of them soon discovered the slitlike entrance to the hive and disappeared inside. They must have been satisfied with their inspection and in some way have told the crowd outside what they had found, for in a few moments after their return every one of the thousands of bees headed toward the one entrance and began marching into the hive in a very orderly manner. They looked like a battalion of soldiers filing into their armory from all sides of the parade ground. There was no confusion and no hurry. The lines of marching

bees formed a beautiful fan converging at the door of the hive.

As I sat there enjoying this unique parade, my eye caught sight of a long, slender bee with a rich red-brown color quite different from the yellow and black-banded

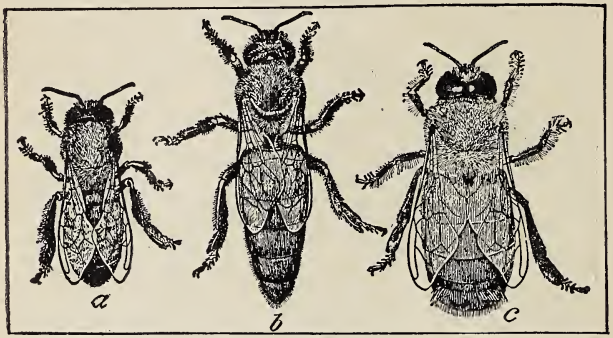
A Swarm of Bees

If the queen bee is one of this buzzing mass of bees, the swarm will follow her into a new home. If she is not among them, the swarm will return to the old hive.

uniforms of the rank and file of the soldiers. I recognized this graceful creature as the queen bee and I was delighted at seeing Her Royal Highness, for I realized that with her present the swarm would accept the home I had provided and would furnish my family with plenty of delicious honey. Sometimes the queen gets left behind or lost dur-

ing the swarming flight. As soon as the bees discover her absence they become very restless and return to the old hive.

That evening after dark I covered up the entrance to the hive. Then I picked up the hive and gently carried it to the spot where I wished it to stand throughout the sum-



HONEY BEES

This shows the three kinds of honey bees: a, worker; b, queen; c, drone.
(Courtesy of the U. S. Department of Agriculture)

mer. Early the next morning the bees came flying out of their new home and flew round and round it in larger and larger circles in order to fix its location indelibly in their minds. If, after they have so fixed their location, their hive should be moved even a few feet away, they would be unable to recognize it as their home. They would sit forlornly on the bare spot where their hive had stood, or they might wander aimlessly about and gradually drift into neighboring beehives. This power of the bees to locate and find their home is due to a homing instinct.

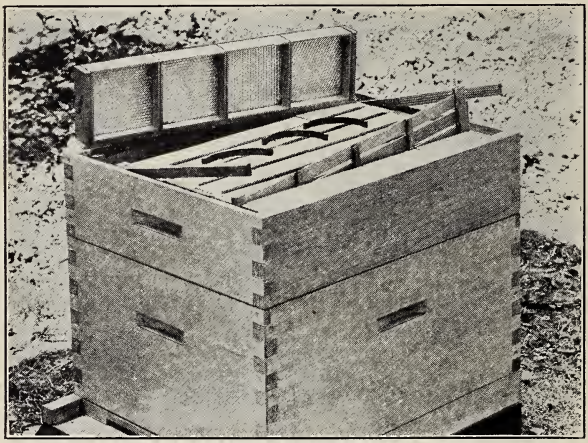
When a bee finishes gathering a load of nectar from the flowers, she makes a bee line for home. Taking advantage of this instinctive habit, men have often tracked wild bees to their store of honey hidden in a hollow tree. The pioneers used to pick a bee off a blossom and, releasing it, note the direction of its homeward flight. By doing this with several bees captured in different parts of the field, they soon had a number of lines all pointing to the hidden nest in a tree. Going to the place where these lines crossed, they found the bee tree, cut it down, and robbed the bees of their great store of delicious honey.

In order that my new swarm of bees might build their honeycomb in such a way that I could easily remove it, I had placed in the hive box a number of wooden frames across which were stretched sheets of beeswax that had been rolled into shape by a machine somewhat like a clothes wringer. The bees seemed to realize that their keeper was trying to help them, for they accepted these sheets of wax and built them up into layers of cells. You have seen in the market similar boxes of honey which the bees had filled for their owners.

Let us now open the beehive and look inside to see the bees at work. If we puff a few whiffs of smoke into the doorway before we do this, we will find the bees less apt to resent our intrusion. As these bees have just started housekeeping in an empty house, we find most of the family hanging quietly in rows, each bee clinging to the legs of the one above so that they form a curtain of living bees suspended from the top of each of the eight wooden frames of wax. Although they hang there so quietly, they are

really very busy digesting the stomachful of honey they brought with them from the old hive when they swarmed.

Out of this honey the bees manufacture the wax with which they build the furniture of their house, the bedrooms and cradles for the children, and the pantries and jars for their supplies of honey and pollen. Each worker bee has

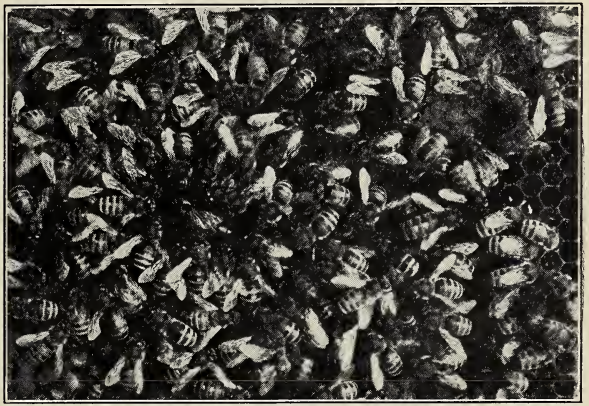


A Modern Beehive
The wax foundations are provided for the bees to build upon.
(Courtesy of The A. I. Root Company)

two rows of glands on her body which exude liquid wax. This hardens into flakes like layers of chewing gum.

When the bees have produced their flakes of wax, they leave the hanging curtain and commence building honeycomb cells on those sheets of wax in the wooden frames. Each bee worker has a pair of shears on each of her hind legs, and with them she clips off the little flakes of wax

sticking out of her body. Putting these in her mouth, she chews the wax until it is soft and pliable, and then plasters this prepared wax into six-sided cups by means of her two black jaws, which look much like a mason's trowel. It is a mystery how these creatures can work all crowded together and yet build those cells in such perfect shape



WORKERS MAKING A RING AROUND THE QUEEN BEE.
(Courtesy of The A. I. Root Company)

and order with never a bit of waste space and never a misfit. This wonderful instinct is born in them.

As soon as the busy bees finish a cluster of the wax cells, the queen comes quietly along and lays a tiny white egg in the bottom of each cell. As she is the only bee in the swarm that can lay eggs, she has to work hard to keep all the cradles filled with baby bees. Some days she lays as many as 1500 eggs, and by the end of the summer she may have a family of 50,000 children, for all the bees in a swarm

are children of one queen mother. The queen bee has the power to lay two kinds of eggs: one that hatches into sons and another that hatches into daughters.

The queen is so busy laying eggs that she has no time to care for her children. Some of the older workers bring up the first brood of baby bees, but after that it is always the duty of the most recently hatched daughters to act as nursemaids for the little sisters. The eggs of bees hatch into small worms somewhat like the caterpillar babies of butterflies. These worm babies are fed a few days on a special kind of predigested honey, called bee jelly. After that they are given bee bread, which is made of pollen and honey mixed together. The pollen is collected by the worker bees from the little powder puffs you have seen in the throat of a lily blossom and from many other flowers.

In about a week these worm babies have grown to full size. They then stop eating, spin a silken blanket around themselves, and go to sleep. The nurses come and plaster wax caps over the tops of the cell cradles so that no one shall disturb their slumbers, for they are going to sleep about a week, during which time their wormlike bodies will transform into bees with big eyes, six legs, and four gauzy wings. They sleep with their heads up so that when they wake they can gnaw through the wax caps and climb out of their beds without any help. At first their wings are wet and crumpled from being wrapped around their bodies as they lay in their tight-fitting cells. These wings are stretched out smooth and even and to full size by the pumping of air through the veins which form the framework to support the gauzy membrane. They soon dry and become stiff and strong.

The young, inexperienced bees do not venture forth into the outside world, but remain under the protecting roof of the hive until they gradually get acquainted. It seems that the bees take turns at the different kinds of work required in a bee colony. The youngest bees serve an apprenticeship as nurses. Squads of older bees stand in the hallways and keep up a circulation of fresh air throughout the warm hive by fanning vigorously with their wings. These bees also fan the newmade honey to thicken it for canning.

Some bees are assigned each day to act as guards at the entrance of the hive, and it is believed that they inspect every bee that enters and that they can tell by smell whether a bee belongs to their family or not. Another set of bees is busy making wax and building comb. A select group of bees acts as a bodyguard for the queen. Wherever she goes she is surrounded by this circle of faithful attendants. They not only protect her with their own lives if necessary, but they feed and bathe her, and do not let her do a stroke of work except to lay her precious eggs.

Most of the worker bees are kept busy exploring the neighborhood in search of those flowers that possess little wells of nectar or sugary sap. The bees and the flowers have formed a kind of partnership in which the flowers give the bees the sweet nectar in exchange for the service of the bees in carrying parcels from flower to flower. These parcels of the flowers are in the form of tiny grains of pollen powder which must pass from one flower to another of the same race in order that the flower may be able to make its seeds. The flowers open their pretty, sweet-smelling blossoms only when they are ready to have their

bee messenger boys carry their precious fertilizing pollen.

The worker bees have a very ingenious way of carrying home their rewards from the flowers. The bee has an extra stomach in which she carries nectar, and this stomach, during the time the bee is flying home, is able to distill the watery nectar into rich, nourishing honey. The bees also receive some of the flower's pollen, which they carry in little baskets on their hind legs. If you will watch the doorway of a beehive on a summer day, you will see on the returning foragers these little baskets so full of red or yellow pollen that they look like colored balls on the legs.

When these heavily laden workers get home, they pour their stomachful of honey into clean wax cups usually just beyond the cluster of cells that form the nursery in the center of each comb. Then they unload the pollen from their leg baskets and stuff it into other empty cells near the honey cells.

The ripening of honey is something like the process of making fruit juices into jelly. Your mother boils the juice, pours it into glasses, and, after the jelly sets, she covers it with wax. The bees pour their honey into wax cups and stand over these while they make a breeze by fanning their wings vigorously. This thickens the honey by evaporation and, after the honey is thick enough, they plaster a wax cap over each honey cup.

With all these activities going on, our hive was a busy place. The swarm gradually grew larger and stronger, and every available place was filled to overflowing with honey. There were many catastrophes, for some of the foragers were gobbled by hungry birds, some of the brave

guards sacrificed their lives in fighting robbers and other intruders, and many bees died from hard work and old age, for the average life of a worker bee is probably not over six weeks. The new bees which hatch every day more than fill the ranks; so the swarm grows to full size by summer time.

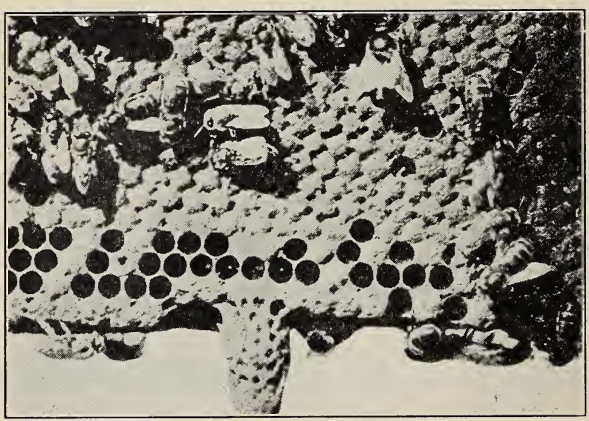
With such an army draining nectar from the countless blossoms of the fields around, honey was being accumulated faster than it was being used by the bees. I therefore added a second story to the hive, and the bees generously filled that for my family's use.

As winter approached, the queen stopped laying eggs, the broods of babies stopped arriving, and the workers cleaned out the empty cradle cells and filled them with honey so that the bees would have plenty to last them all winter. During the winter the bees huddle close together over the combs of honey to keep warm and to get something to eat without moving.

With the arrival of spring the bees wake up from their winter sleep and clean their house in preparation for the busy summer season. The bees that survive the winter live long enough to help the queen raise a new brood, and then they gradually die off. Usually by May the hive is filled with young, vigorous bees, and some instinct tells them that it is about time to swarm. Swarming is the bees' way of making new colonies of bees by dividing an overgrown colony into two.

Since a bee colony cannot get along without a queen, it becomes necessary to get another queen before the colony is divided. This instinct causes the workers to do several things not on their everyday program. They begin by

building different kinds of cells. They build a number of the regular six-sided cells, but of a slightly larger size. In these the queen mother promptly lays the kind of eggs that will hatch into sons, or drones, as they are called. The workers also build a few large hanging cells that remind



THE QUEEN CELL

The peanutlike mass hanging down from the comb is the queen cell. The worker babies are raised in the small honeycomb cells above. The queen baby is reared in a large isolated bedroom and is fed upon royal jelly which makes her grow into a princess instead of a common laborer.

(From *Marvels of the Universe*)

one of peanut shells. These are queen cells and in them the queen lays eggs that will become baby queens.

It is a strange thing that these eggs are exactly the same as those that usually become workers. But the queen babies are fed upon different food and given a larger cradle.

The queen baby never is given the bread-and-honey diet of her worker sister, but is fed throughout her worm babyhood on rich bee jelly. This food which makes a baby grow into a queen instead of a worker is called royal jelly.

Just before it is time for the queen baby to hatch out of her royal cradle, the old queen gets ready to move out of the hive. Scouts are sent out to hunt up a house to rent, which usually means a convenient hole in a hollow tree. Then the bees wait for a suitable day, for they always seem to choose a calm, warm, sunshiny day. Apparently they sound some kind of signal for the departure, for about half the workers in the hive rush to the honey pots and fill their stomachs to capacity with provisions for the journey. This load of honey is all that they take of their possessions, for they leave behind them forever their house, all the furniture, all the eggs and baby bees, half of the servants and workmen, and all the food supplies except the lunch each one carries in its stomach.

When all is ready they take the queen mother with them and rush out of the entrance and go swirling off into the air as a ball-like mass of buzzing bees. We learned at the beginning of this chapter how they stopped to rest on a plum tree and were invited to move into a nice new house by a friendly gentleman who gave them their rent in exchange for a few pounds of honey.

What other mother would give up her home and possessions for a daughter she had never seen and go empty-handed and homeless into a world to start life all over again?

Questions

1. How did the man capture and hive a swarm of bees?
2. When and how does a swarm of bees fix the location of a new home?
3. How do bees behave if their hive is moved after its location is fixed?
4. How do bee men track wild bees to their home?
5. How does the bee keeper get the bees to put their honey in little boxes?
6. How does he quiet the bees so that they will not sting him?
7. How do bees make wax?
8. What work does the queen do?
9. Who nurses the baby bees?
10. Describe the babyhood of a bee.
11. What different kinds of work do bees take turns in doing?
12. Describe the partnership of the bees and flowers.
13. How do bees carry nectar and make honey?
14. How do they carry and store pollen?
15. How do the bees spend the winter?
16. Why do bees swarm?
17. How do bees get a new queen?

CHAPTER XIII

SILK SPINNERS

WE marvel at the beauty of a piece of shimmering silk and delight in rubbing our fingers over its smooth surface. But we marvel still more when we come to realize that the lustrous silks from all the looms in all the wide world were first made, not by man, but by worms. These worms are the caterpillar babies of creamy white moths which were discovered thousands of years ago in China. They were domesticated by the Chinese and have given their services ever since to the human race. The Chinese gradually learned to raise these silkworms in captivity in much the same way that poultrymen hatch and brood chickens. Silkworms are now raised in Italy, France, China, and Japan.

In Japan silkworm raising is now as common an occupation in the home as chicken raising is in America. In the back yard of a Japanese home is a bamboo tentlike house which serves as a home factory and is filled with thousands of worm workers producing each year a crop of valuable silk for the benefit of the family. Here come two little daughters to do their part in this family industry. Each little girl is dressed in a flowered silk kimono, with a broad ribbon sash tied behind in a big bow that looks as if it might serve as a nice pillow if she fell over backward. Her black hair is parted in the middle and done up in two big loops at the back. Since there are no chairs in a Japanese home, the girls rest on their knees

on the woven grass rug that covers the floor. Their work this morning is to take charge of a basket of silk cocoons and oversee the hatching of the creamy white moths from them.

First they take clean sheets of white paper and tack them on a long board frame. On these sheets they place the moths as fast as they crawl out of their silken beds or cocoons. Even the wild silk moths do not crawl very far from home — only far enough to climb upon the leaves of the trees — and these tame moths whose ancestors have been raised in captivity for ages are less active and do not attempt to crawl off the sheets of paper during their brief lifetime of only three days. During these three short days they crawl about on the sheets of paper, laying over three hundred tiny yellow eggs which stick to the paper wherever they are dropped. The moth does not eat any food while she lives in the moth stage.

The Japanese girls, after placing the moths on these sheets of paper, watch over them until all their eggs are laid, and then place these precious sheets of eggs on bamboo trays arranged one above another on bamboo racks. If it is warm weather the eggs will hatch in about ten days. It is possible to postpone their hatching for an indefinite time by keeping them in a cool place like a refrigerator. Advantage is taken of this fact to ship eggs of silkworms from Japan, China, France, or Italy to the United States and other countries where the industry has not yet been established. Our Department of Agriculture will supply silk-moth eggs to schools in order that teachers and pupils may watch the spinning of silk and experiment with the silk industry in their own locality.

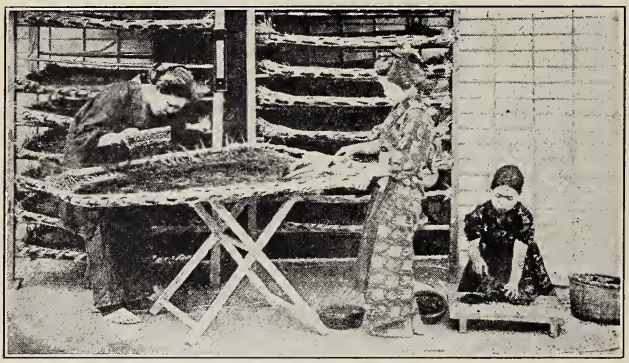
These eggs will hatch in a short time after they are placed in a warm room or in an incubator. It is necessary to plan to receive the eggs at just about the time that the mulberry trees are leafing out in the spring, for the worms must have the tender young leaves for their food. Silk raising has not proven a success in America because of the great amount of labor required and the fact that it must be done in competition with the very cheap labor of other countries.

We will now go back to our little Japanese family working away with their silkworms. The eggs are now hatching, and tiny brown caterpillars are crawling about over the sheets of paper. These are only about a sixteenth of an inch long. They have bullet-shaped heads with two strong black jaws and a cluster of pinhead eyes that can distinguish only the difference between day and night. The body is a long tube cut up into twelve ringlike pieces with eight pairs of stumpy legs and nine pairs of tiny pin-prick holes scattered along the sides of the rings. Most of the legs have claspers that enable the worm to hold to the twig or leaf upon which he is crawling. The pin-prick holes are the ends of breathing tubes that branch like roots all through the inside of the worm's body.

The Japanese girls prepare a dinner for the baby worms by chopping up fine some tender young mulberry leaves. The boys in the family have already gathered a basketful of these leaves from the rows of bushes they raise in their back yards in much the same way that we raise corn in our gardens. To keep the bushes growing tender shoots, they keep cutting them down to the ground so that they will sprout new growths.

After the girls have chopped up the leaves, they spread them over a coarse net cloth stretched on a bamboo tray. When this is placed gently down over the tiny worms on the papers, they crawl up through the holes on to the leaves and nibble away at the juicy food.

Each morning a clean tray of fresh food is placed above the worms and, as soon as the worms have all climbed up,



FEEDING BABY WORMS

The little lady at the right is chopping up tender mulberry leaves which the other women are scattering over the tray of baby worms.

(Courtesy of The Belding Carlson Currier Silk Company)

the lower soiled tray is removed. These trays are washed clean and left out all day for the sunshine to dry and kill any germs that might make the silkworms sick.

The worms have very good appetites and they eat all day and all night. This keeps our little Japanese friends busy. The worms keep eating and growing steadily for about a month. By that time they have become

nearly three inches long, or about 14,000 times bigger than they were when they were hatched. In fact, they grow so fast that they outgrow their skins, which split open along their backs about once a week. In the meantime the worm has grown a new skin inside his old one; so he just crawls through the split in his back and goes right on with his steady job of eating and growing. Each time the

SILK WORMS FEEDING

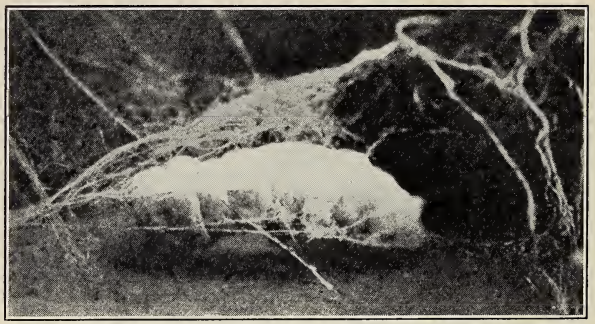
The worms at first merely suck the sap out of tender young leaves, but after a few days they are able to chew the leaves with their powerful jaws.

(Courtesy of The Belding Carlson Currier Silk Company)

worm molts or sheds his skin he becomes lighter colored, and gradually changes from brown to ashy gray. As he gets older he eats larger and older leaves, and the girls do not have to chop up his food for him.

As soon as the worms are fully grown, they lose their appetites and become very restless, wandering aimlessly about, swinging their heads, and trying to climb up on

anything in their way. They are now getting ready to spin their silk cocoons, inside of which they go into a strange deathlike sleep. During this sleep their worm bodies will disappear and be replaced with winged moth bodies. Their Japanese attendants understand what is going to happen and prepare a special tray covered with a straw mat crinkled up and down like the corrugated paper



A Worm Spinning its Cocoon

The worm first spins a hammocklike support over the straw provided by the attendant. Then, by twisting its head, it winds silk around itself until it has formed a silk cocoon something like a peanut shell. A thread about 1000 feet long is required for the cocoon.

(Courtesy of The Belding Carlson Currier Silk Company)

used in packing boxes. The worms crawl up on this bed and select places where they will build their cocoons.

The worm now begins moving his head up and down, and around and around, and you can see that a tiny silk thread is coming out of his mouth. By using your magnifying glass you find that this thread is pouring out as a thick liquid from a tiny hole or tube in his lower lip. It

reminds you of tooth paste being squeezed out of its tube onto your brush. The stream of liquid silk, as soon as it strikes the air, hardens into a strong silk thread.

At first the worm weaves this thread here and there over the straw until he has made a fluffy, netlike nest. Then he begins a regular double, or figure-eight, movement of his head about his body so that he winds himself up inside a hollow spool of thread. For three days and three nights this thread keeps flowing continuously out of his lip. At the rate of about seventy times a minute for all these dizzy three days and nights, he twists his head 30,000 times around his body, until he has wound a continuous thread of eight hundred feet or more into a hollow spool about the size and shape of a peanut shell.

Having completed this very strenuous task of manufacturing out of his own body some thousand feet of thread, he has wound it into a cocoon so tough that you cannot tear it, and it is so tightly woven that it is waterproof. Then he lies down and has a good sleep. After sleeping four or five days, he wakes up long enough to molt his caterpillar skin for the last time. He wiggles out of this skin, which is always found tucked down in the bottom of the cocoon after the moth comes out. Instead of the ashy gray caterpillar with sixteen legs, we now find a queer object with a roly-poly shape and a brown leather covering that does not resemble either caterpillar or moth — in fact it does not seem to be a living thing at all. But by looking closely at it we can see through the leather coat the outlines of the feathery feelers and the gauzy wings of the moth that is to be.

After lying there asleep for about ten days this queer

thing splits open along one side, and out through this crack (which proves to be the back of the neck) crawls forth a wet, bedraggled-looking moth. It then pours out of its mouth a fluid which softens the gum that had glued together the threads of the cocoon, and then it pulls the threads apart with its claws and squeezes through the opening. The little Japanese maidens are waiting outside. They pick it up very gently and place it on the sheet of paper where it dries its wings; and then for three

MOTHS ESCAPING FROM COCOONS

When the body has been transformed from worm to insect, the creature sheds its covering and crawls out as a moth. It spits out a juice that softens the silk threads at the upper end of the cocoon, tears its way through these threads, and crawls out as shown in this picture.

(Courtesy of The Belding Carlson Currier Silk Company)

days, without stopping to eat, it lays its hundreds of eggs. Having then fulfilled its mission, it lies down and dies.

Since our Japanese family depend upon the silk for their own livelihood, they are obliged to interrupt this natural course of procedure. When the worms finish making their cocoons on the straw mat, the girls gather them up, the pretty golden yellow ones and the lovely snow-white ones. They examine them very carefully and choose the finest

ones to be kept and allowed to hatch out into moths to furnish eggs for the next crop of silkworms.

These choice cocoons are placed on trays and allowed to complete their change from caterpillar into moth and to hatch out, even at the expense of ruining the silk by breaking all the threads in making their escape. One hundred female moths should lay one ounce of eggs. These eggs should hatch into 40,000 caterpillars, which should eat about 1200 pounds of mulberry leaves to spin about 190 pounds of raw silk worth an average of five dollars a pound.

All the rest of the crop of cocoons are given a steam or hot-air bath which kills the sleeping caterpillars inside and prevents them from changing into moths and breaking the silk threads in their efforts to escape from their cocoon prisons.

After the caterpillars are killed, the silk threads must be carefully unwound from the cocoons. The threads are then twisted together and reeled into skeins. Then this raw silk, as it is called, is shipped to various parts of the world to be manufactured into cloth.

The care of silkworms and the raising of silk cocoons is done largely by the peasants of Oriental and Mediterranean countries like China, Japan, Italy, and France. Most of the silk manufacturing is done in great factories with the aid of very wonderful and very complicated machinery. There are some very fine modern factories in these countries, but most of the manufacturing of raw silk into cloth and spooled threads and embroidery flosses is done in the United States.

These American silk factories are models of sanitation for the protection of the health of their employees, and of

ingenuity and economy for the profitable production of the finest goods. The machines are so wonderful that they seem almost to think. If a single thread among the thousands running through one of these complicated machines breaks, the machine will automatically stop so as not to tangle all the other threads into a hopeless snarl or to injure the delicate machinery. So first we marvel at the wonderful ingenuity and perseverance of the worm spinners of the cocoons, and then we marvel at the mechanical inventiveness of the human manufacturers. Meantime we are using more silk every day for clothing.

Questions

1. Where were silkworms first discovered?
2. What things do the silk moths do in their short lifetime?
3. How does man control the time of hatching of the silk moth's eggs?
4. How might you get some eggs to experiment with?
5. Describe the silkworm caterpillar.
6. What and how are silkworms fed?
7. How do the attendants keep the worms clean without handling them?
8. How fast do silk worms grow?
9. What happens because they grow so fast?
10. Where do the worms put their cocoons?
11. How does the worm make the cocoon?
12. What happens inside the cocoon?
13. Why do the attendants save some cocoons and kill the rest?

14. How do the girls unwind cocoons?
15. Where is most of the raw silk of today raised?
16. Where is most of the manufacturing of silk goods done today?
17. What do you know about imitation silk, such as fibre silk?

CHAPTER XIV

INSECT ORCHESTRAS

WHO has not been thrilled by the songs of birds — the "cheer-up" of the robin after an April shower, or the rollicking song of the bobolink as he sails above the prairie? Birds are nature's choristers who have forever filled the world with music. They are so conspicuous with their happy songs and bright colors that they are known to every one who has ever lived in the country.

But how many of us are acquainted with nature's orchestra, whose fiddles, drums, and piccolos are played by insect musicians so small and timid that they are seen by only those who have the patience and the keenness of observation of an Indian? Go out into the fields on a quiet summer day, or stand and listen in the woods in the dusk of evening, and you will hear the fiddling and drumming of countless tiny unseen performers.

Birds are true songsters and have a music box in their throats very similar to the voice box of the human prima donna. Insects have no voice box in their mouths and so do not sing. Their music boxes are like stringed instruments. They make their music with their wings and legs or with tightly stretched membranes like the heads of drums. We may compare them to our symphony orchestras.

Only certain kinds of insects ever become musicians.

No insect musician ever has to learn to play his instrument or spend tedious hours practicing scales or exercises. Every insect is born with his instruments as a part of his own body and he can play them just as easily as you can breathe. There is one unfortunate thing about being born with your musical instrument: you can play but one tune and can never learn any new ones. Insects are creatures of instinct; this means that they inherit all their behaviors and skills, and must do everything just as their parents did.

There is just as much difference between the instruments of insect orchestras as there is between the drums, fiddles, and horns of our orchestras. Some beetles make clicking or snapping sounds by creaking the joints of their stiff metallic armor. One sort has a spine on his breast which he pushes in and out of a socket in his shell. He does this to give himself a jerk so that he may throw himself into the air to escape a hungry bird or lizard. This makes a clicking or snapping noise. He is therefore called the click beetle. There are some kinds of beetles which bore into furniture and make a steady ticking noise by tapping their heads on the wood. This, when heard in the dead of night, was assumed by superstitious people to be a "death watch" ticking off the minutes of life of the next member of the family about to die.

You have probably been startled some time, while trudging along a dusty road through the farmer's fields, by the sudden flight of a dust-colored grasshopper with colored wings which made a loud clacking noise as he flew by, striking together his hard horny wing covers. Such simple instruments remind one of the clappers of various

kinds played by the man in the orchestra who handles the drums, cymbals, and triangles.

What noisy fellows are the house flies, especially when they get caught exploring a bottle! What an annoying noise the mosquito makes as she sounds her tiny horn in your ear while she hunts for a place to stick her stiletto into your tender flesh! These flies and their cousins, the mosquitoes, make their music by beating the air with their wings, which produces a humming or buzzing sound. In order to hear these sound vibrations, the male mosquito has his feelers made in the form of bushy whiskers which act like pigmy tuning forks and vibrate in unison with the sounds heard. One student glued a male mosquito on to a glass slide under a microscope and watched the whiskers vibrate 512 times per second, in tune with a tuning fork of pitch C, when a female mosquito held close by made her whining sound for him.

Bees, wasps, and hornets make their noises in much the same way, but they seem to be able to vary the sounds to express their feelings. One bee-keeper with very keen hearing and an unusual appreciation of music claimed that he could tell by the sound of his bees' "voices" what they were saying.

The locusts, grasshoppers, and crickets are among the best of insect musicians. They occur in countless swarms and constitute the mighty orchestras that fill the air with din or music according to the musical appreciation of the hearers. These insect musicians all play fiddles which are made of wings and legs. The common grasshoppers of the fields make their chirping noise by rubbing the inside of their thighs over the outside of their stiff wing

covers. There is a rough ridge on the inside of the leg and a raised vein on the wing. These make a grating noise like a file as they are scraped across each other.

The meadow grasshoppers with long threadlike feelers have ridges like files on both of their wing covers. They rub one wing over the other in such a way that these files scrape each other. In order to magnify the sound of the files, they have a tightly stretched part of the membrane of the wing close to the file, which acts like the sounding

GRASSHOPPERS' EARS

Several species of grasshoppers wear their ears on their knees. The ears are little membranes stretched across the mouth of a cavity in the leg. These act somewhat like the receiver of a telephone, only the vibrations are carried by a nerve impulse instead of an electric current.

(From *Marvels of the Universe*)

box of the violin. It greatly increases the tones of the vibrating strings.

As only the males have these files and membranes on their wings, and as the females have bigger ears, it is supposed that the males use their fiddles to serenade their mates. The ears of insects, by the way, are not at all like our ears. The common grasshoppers have tiny skinny drums on their sides under the base of the wings, while the

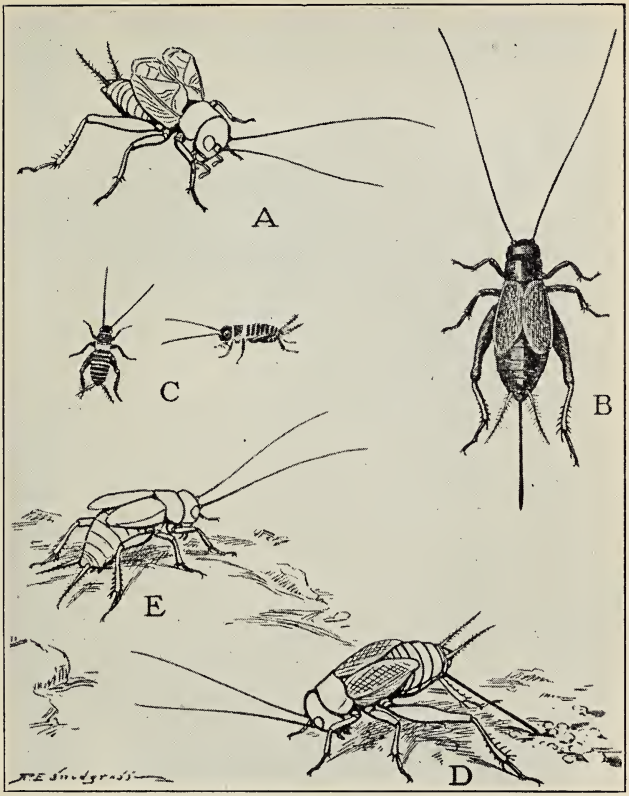
meadow grasshopper and the crickets have membrane-covered slits in their front legs. They hold their little wrist-watch ears up toward the fiddles of their serenaders.

The cricket on the hearth has been a companion of civilized man since time immemorial. Apparently the house cricket is never found living anywhere except in the warm houses of men. His song is so associated with the peace and comfort of the home that it is loved by all peoples and has been the subject of song and story.

> On a lone winter's evening, when the frost
> Has wrought a silence, from the stove there shrills
> The cricket's song.

The cricket's fiddle is much like that of the meadow grasshopper, except that he uses his right wing as his bow while the grasshopper uses his left. It is a mystery why the cricket has files on both wings when he uses only one. One experimenter carefully slipped the left wing over the right, but the cricket immediately slipped it back and refused to fiddle with the left bow. The man then took a baby cricket and reversed its wings. This insect grew up with the left one on top and fiddled lefthanded. One observer claims that the field crickets fiddle in unison. At first, while they are tuning up, they do not keep together, but after a while they keep time. He noticed that when one stopped to rest he took up his note again in time with the rest of the orchestra.

The males seemed to vie with one another, each getting louder and louder until he had to stop and rest and start over again. They seemed to pay no attention to the female crickets. This caused one author to say: "The



CRICKETS

A. Male with wings rubbing together to make the chirping sound.
B. The female cricket. C. Baby crickets.
D. Female starting to lay her eggs in the ground.
E. Female with her egg layer plunged into the ground.

(Courtesy of The Smithsonian Institution)

cricket sings to express himself and not to charm the females. In fact it is hard to feel certain whether he is singing or swearing. The cricket, like an opera singer, simply expresses all his emotions in music, and whether we can understand the words or not, we understand the sentiment."

The male of the tree cricket has a little hollow, or cup, on his back between his wings which is filled with a sweet liquid like nectar. When he fiddles he raises his wings high over his head so as to uncover his honey pot. As he fiddles, a female slowly approaches until she finds the honey, and then helps herself to the honey-drops provided by her serenader.

Another famous musician is the katydid. This is a long-horned grasshopper with broad wing covers that look like green leaves and which undoubtedly help to disguise the insect. He dwells in the lonely places of the quiet forest and has a fiddle like his cousin, the meadow grasshopper. Occasionally a glimpse may be had of the musician as he plays. He most frequently stands with the head downward, the body braced stiffly on the legs, the front wings very slightly elevated, the tops of the hind wings projecting a little from between them, the abdomen depressed, the breathing hard, and the long feelers waving about in all directions.

Each syllable appears to be produced by a separate series of vibrations made by a rapid shuffling of the wings, producing the sound *ka-ty-did,* repeated regularly sixty times a minute. Some have two notes, one for day and one for night. Scudder noticed that they changed when the sun went under a cloud and again when it came out.

Some katydids make two successive scrapings of their bows while others make three; thus some seem to say *ka-ty* while others say *ka-ty-did*.

The star performer among insect musicians is the cicada, or seventeen-year locust. This is a queer bug that lives for sixteen years underground, as a wingless grub, on the roots of a tree. In the seventeenth year it grows wings and digs its way up into the air and sunshine. Cicadas are lusty drummers whose *rat-a-tat* sounds like the buzz-saw in a saw mill. They are typical mid-summer musicians and are responsible for much of the din of the dog days of August. While it is said that the ancient Greeks kept these lusty drummers in gold cages as we do canary birds, most of us would prefer the sweeter and gentler toned crickets which are kept as pets by the Japanese.

It is the ingenuity of their instruments that gives the cicadas or locusts first rank among insect musicians. Their drums are located under their abdomens, covered with a protecting tough skin, and consist of two tightly stretched drum membranes separated by a large air space. They are beaten, not by drum sticks, but by being pulled back and forth into rapid vibration by powerful muscles. It reminds me of a tambourine as I saw it played lately in an orchestra. The player held the tambourine in one hand and set it to chattering by wetting his finger and rubbing the end of it across the membrane. The spasmodic jerks of the cicada's muscles act like this "stuttering" finger.

The air space and inner drum membrane are believed to act as a sounding box to magnify the sound, which can be heard for about half a mile. In order that these large drums may be accommodated inside his body, the other or-

gans of the cicada are crowded into corners and out-of-the-way places. As one man said: "The cicada must think a lot of his music to be willing to put up half his house for his music box."

Next vacation, while you are free to live much out of doors and to camp in the wilds, try to tune in on the orchestra of the many insect musicians.

Questions

1. How do the musical organs of insects differ from those of birds?
2. Why do insect musicians never have to practice or learn new pieces?
3. What queer noises do some beetles make?
4. How do flies and bees make their humming or buzzing noises?
5. Describe the grasshopper's fiddle and the way he plays it.
6. What kinds of contests do crickets have?
7. How does the green grasshopper say *katydid?*
8. Who is the star performer in the insect orchestra?
9. How does he beat his drum?

CHAPTER XV

SPOTTED BEAUTY

IT was a hot July day and Carol and I were sitting on the grass in the shade of our vine-clad porch. The honey bees were buzzing in and out of the blossoms overhead, and now and then a butterfly flitted lazily by.

"What a lot of spiders, and how busy they are!" exclaimed Carol.

"Well," I answered, "fly time is spider time, and they are busy hanging up their sticky fly-paper traps to catch flies for their suppers. Let us watch Mrs. Spider spin her web."

We soon noticed that there were several kinds of spiders spreading their traps over the front of our porch. Apparently they get along happily with their neighbors, for in some places the webs were within a few inches of each other. One spider had even anchored her web to the main guy rope of the web of a different species of spider.

I noticed a pretty little spotted creature of the garden-spider variety sleeping under a leaf of Virginia creeper, and suggested that we watch her when she waked up. Since it was already about four o'clock in the afternoon, we did not have long to wait. The late afternoon is the busy time for the spider family.

Spotted Beauty, as we named her, stretched her eight long legs and peeked out upon the world through the eight shiny eyes on the back of her velvety head. Scien-

tists who have studied the ways of spiders think that they can see clearly for a distance of only a few inches. Under these circumstances it is a mystery how spiders lay out their webs over spaces sometimes covering as much as ten feet.

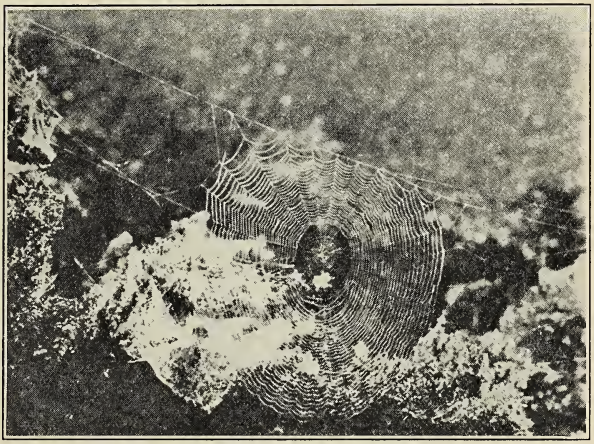
Spotted Beauty scrambled up the vine on the porch and crawled out to the tip end of an ivy leaf dangling eight feet above the ground. Fastening a silk thread to the leaf, she let herself drop off into space, dangling on the end of the thread which she slipped through the grasp of her long hind legs. Surely spiders invented fire escapes long before man ever thought of such things.

When Spotted Beauty had fallen about six feet, she stopped herself suddenly by grasping the thread with her feet. Swaying about on the end of her rope, she was finally wafted near enough to the top of a fern frond to grasp it with one of her long legs. Climbing upon this leaf, she pulled in the slack of her thread until it was taut, and then glued the end firmly to the leaf. She now had a suspension bridge across the chasm from the leaf to the fern. She walked tight-rope fashion over this bridge several times, spinning more and more threads to make it very strong, for this was to become the main support of her fly trap.

Next she fastened some guy ropes from this suspension bridge to several other leaves near each end to form a set of strong braces. Then she climbed from leaf to leaf around the boundary of the open space between the ferns, which she had evidently selected for her hunting ground. She had fastened one end of a thread to the main tight rope when she started, and we could easily see that she

was carrying this loose thread in one of her hind legs and was gluing it fast to each leaf as she passed, so that she made a zigzag frame of taut threads around the open space and back to the suspension bridge.

Climbing out on her suspension bridge, she fastened a



SPOTTED BEAUTY'S WEB

This picture shows the suspension bridge, some six feet long, from which the web is suspended. A few of the framework cables are also visible. It also shows all the spikes upon which is laid the spiral snare of sticky threads that catch the feet or wings of fly or moth.

(From *Marvels of the Universe*)

thread at its middle point and then carried the loose end back and around the frame to the opposite side of the open space, where she pulled it tight and glued it to the frame. Using her front legs, she climbed hand over hand up this cross thread until she reached the center. Here

she fastened the first of a series of radiating threads that were to become the spokes in her wheel-shaped web.

Always carrying the running thread in her long hind leg so that it could not get tangled in the thread she was walking on, she brought it down to the end of the last spoke and then out along the frame a little way. Then she ran up to the center again and pulled up the slack on this new spoke and glued it fast to the little button of silk at the hub. If she had spun the spokes one after the other around the circle, the wheel would have been pulled out of shape. She seemed to test the tightness or looseness of the framework by pulling the spokes with some of her legs, and then put in the next spoke wherever she thought necessary to keep the growing wheel evenly stretched. As we watched closely, we found that she put in new spokes first on one side and then on the other, some at the top and some at the bottom.

Spotted Beauty spun twenty-one spokes, one after the other, as fast as she could run. Without a moment's hesitation she placed them so evenly that our eyes could hardly detect a difference in the spaces between them. Scientists who have watched spiders for long periods of time claim that every spider of the same species always makes the same number of spokes in its web, regardless of the size or shape of the space the web is to occupy.

"What student in your geometry class could divide a circle offhand into any given number of sections without measuring the circle or using dividers?" I asked Carol. Spotted Beauty does this easily and perfectly the first time she tries, because she does it by instinct or a kind of ready-made knowledge born within her.

Now Beauty had completed her beautiful gossamer wheel in its irregular zigzag framework and had stretched it smoothly between the ferns on the ground and the ivy hanging from the porch. Without stopping to rest, she ran to the center of the wheel and began walking round and round over the spokes, trailing over them a long spiral thread. At first she spun this thread in close spirals to form a little mat or platform at the hub, and then spread them farther and farther apart so that there were only six widely separated turns over the outer part of the wheel. She was building this spiral as a temporary scaffold upon which she could walk while laying the real floor of her wheel. You have seen carpenters build similar scaffolds around houses under construction in order that they may comfortably put on the siding and fit in the windows.

Having finished her scaffold, Spotted Beauty turned right around and began to run back along the spiral thread. You could easily see that she faced toward the hub so that her spinning hind legs stuck out quite a distance toward the outer frame and that she was laying down a new kind of sticky, glistening silk thread. These sticky threads were laid down so close together that she strung eight rows of them while walking eight times around on the first round of her scaffold. As she went around the last time, she did a queer thing in order to make room for the next spiral of the sticky thread. She snipped off the scaffold thread, rolled it up into a ball with her jaw fingers, and calmly swallowed it as she went on laying her sticky coil.

Fabre, the great French naturalist, discovered that spiders thus economically use the scaffold silk by digesting it into new liquid silk to be secreted again in the

form of new threads. What a saving if a carpenter could take the splintered and sawed-up boards of a torn-down house and make them overnight into brand-new boards!

Spotted Beauty went right along with her spinning, and we found that she had completed about thirty rows of the sticky coil and had removed all the scaffold except the little mat at the hub, which she intended to keep for a resting place while she watched for flies. By looking at my watch I found that Spotted Beauty had constructed within one hour this beautiful, very complicated design, fitted nicely into an irregular leafy space and stretched as smoothly as the strings of a tennis racket.

Her strenuous labor finished, she ran in to the center and stretched herself out on her little mat with her head down and her pretty spotted back toward us. We left her resting there while I explained to Carol a few of the interesting things we could not see with our naked eyes.

Spotted Beauty has six tiny spinning fingers underneath the end of her abdomen. Under a microscope they look much like your fingers all bunched together. She can bunch them close together to spin a large cable of several strands or she can spread them out to spin a flat ribbon of silk such as you see zigzagging through the center of the web of some of the garden spiders.

Under the microscope each spinning finger looks like a tiny thimble with each little depression the opening of a tiny tube out of which liquid silk can be poured. The moment the nearly two hundred streams of liquid meet the air, they harden into silk threads and become stuck together into one large thread that resembles a rope made of several strands, with dozens of separate fibers in each

strand. The silk thread is so strong that it easily bears the weight of the spider as she swings down through space on the end of it. Being a sticky liquid, it will stick fast to anything it touches. This makes it easy for the spider to fasten a new thread by merely touching the tip of her spinning fingers to any object.

The spider either makes a thread by letting her body fall after fastening the end of the thread, thus drawing out the thread like a string coming out of a rolling ball, or she pulls the thread out with one hind leg and passes it wherever she pleases with the other leg. Sometimes spiders do not want to drop straight down as our Beauty did, but wish to reach horizontally across from bush to bush or from fence to barn. In that case they climb to the top of one of these objects and stand on their heads and front legs while they spin silk which they pull out with their hind legs and allow to float out on the breeze. This little streamer of fluffy silk will float up and outward like a boy's kite on the end of its string. The little kite of silk goes floating away, dragging a thread of silk out of the spinner, until it finally lands on some distant object like a fence, tree, or barn. As soon as this streamer is caught fast the spider pulls in the slack until she thinks the thread is tight enough to suit her purpose; then she glues it to the thing she is standing on. She has very ingeniously thrown a tight rope across what must seem to her to be a great chasm, just as an ingenious man once flew a kite across the roaring torrent of the Niagara River, and then pulled across larger and yet larger cords until he had a suspension bridge that would hold up a man.

Baby spiders sometimes use this method in order to

travel about the world in search of a good place for a home. They climb up to an elevation and spin out a little balloon of fluffy silk which is caught by a passing breeze that pulls out more and more silk. It pulls harder and harder as it sails up into the sky until it finally tugs so hard that it pulls the baby spider off his little feet and wafts him off on a voyage of adventure and discovery. One of our great naturalists, while traveling across the ocean, observed hundreds of baby spiders sailing calmly out over the sea some sixty miles from shore. I wonder how many of those venturesome tiny Lindberghs managed to pilot their miniature airplanes to a successful landing.

Let us now see why our Spotted Beauty labored so hard this hot summer afternoon to build a delicate, intricate, silken handkerchief that in all probability will be torn to shreds before tomorrow morning dawns. Her food is live flies or other small insects. She could not well catch these without help, because they can fly while she can not. With her silken threads she is able to construct a snare so fine that the fly cannot see it and so strong and sticky that the fly cannot tear himself loose when he gets his legs or wings tangled in it.

The framework and spokes are made of strong, non-sticky silk that does not stretch and forms a support for the spiral coil of very elastic, sticky threads which catch the unwary fly or moth much as does the manufactured sticky fly-paper. Fabre found that the sticky threads are really very tiny hollow tubes containing a liquid glue that keeps oozing through to the outside, with the result that the snare does not lose its stickiness for a long time.

These tubes are twisted like coiled springs and stretch easily while the frantic fly is struggling to pull himself free, but they pull him right back again as though they were rubber bands.

"I am wondering why the spider does not get stuck fast in her own snare," said Carol.

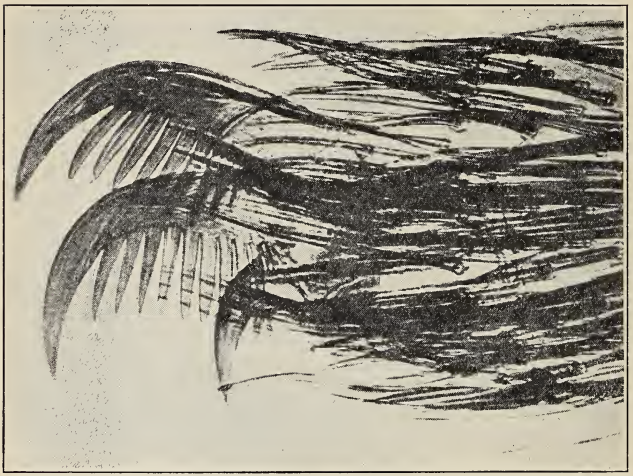
She steps only on the smooth radiating spokes, for she seems to be able to keep track of where she places her eight feet as easily as you do your two when you walk over the squares of a cement sidewalk without stepping on the cracks.

Fabre made some interesting experiments that explain why the spider never gets caught in her own web. He oiled his finger, a straw, and the leg of a grasshopper, and then found that none of them would stick to the spider's web. He washed the legs of a spider in some fluid that dissolves oil, and discovered that the spider got tangled in her own web as hopelessly as any fly. He believed that the spider sweats out an oily fluid all over her body which safeguards her from getting caught in her own trap.

We left Spotted Beauty resting quietly on her sleeping mat at the hub of her web. Presently there was a shower of tiny particles shaken down over her web by the bees scrambling over the blossoms in their search for nectar. Some of these little petals fell through the open meshes of the web, but others stuck fast to the sticky coil. Out ran Beauty to see whether she had caught some flies for her dinner. Finding instead a lot of trash scattered all over her carpet, she proceeded to pick up the pieces one at a time in her curved mouth-fingers. Then she handed

them back to her front legs, which poked them out through an opening in the web and dropped them upon the ground.

While she was again lying motionlessly in wait on her little mat, a careless fly came buzzing lazily along, parallel



A Spider's Foot

This greatly magnified view of the toes of a spider shows that each toe is like a fine-toothed comb which prevents the spider from slipping.
(From *Marvels of the Universe*)

to her web. The watchful spider quietly spread her eight long legs out so that each one had hold of a spoke, and suddenly she gave her web a violent shake that made it flap back and forth like a rug being shaken to get it clean.

"That was a clever trick by which Beauty tried to slap her sticky fly-paper upon the fly without waiting for him

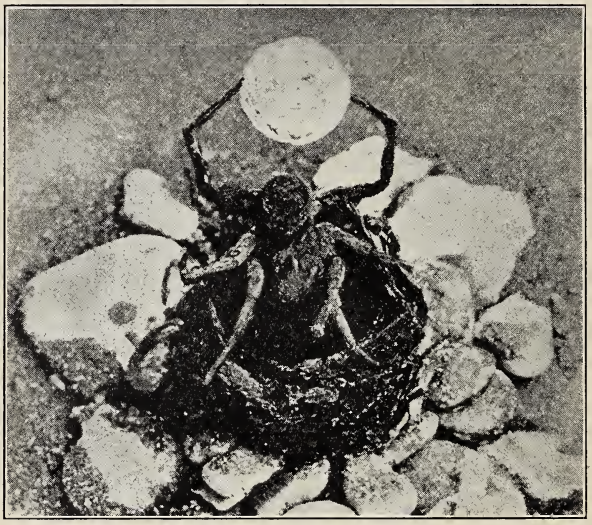
to blunder into the trap," said Carol. Fortunately for Mr. Fly, he happened to be just out of reach; so he escaped sudden death, though I could not see that he appreciated the fact.

Carol was getting impatient to see Beauty catch a fly and eat her dinner; so she took her butterfly net over to the flower beds in the sunny garden and soon returned with a goodly supply of flies. Pinching one so that it could not move, she dropped it into Beauty's snare. Like a flash Beauty dashed out, seized the struggling fly in her front legs, and whirled it over and over as a circus juggler whirls a barrel on his upturned feet. All the time she was whirling the fly she was winding silk threads around and around his body and legs till he was literally bound hand and foot. This is a very ingenious way of handling her victims, especially any insects that might sting her to death.

Picking up her helpless prey, Beauty carried it to her resting mat and sat down to enjoy her supper. Spiders do not chew their food, but suck out all the juices and then throw away the empty skin. When Beauty had finished, Carol gave her another fly which she promptly seized but did not seem to be hungry for. After binding it with silk, she carried it to the edge of the web, lowered it down through a mesh, and left it dangling on the end of a thread, to be eaten at her leisure or when she was more hungry. Spiders do not kill insects they hang up in this way; they bite just enough poison into their victims to make them lie in a kind of stupor, for in this way they do not spoil as they would if dead.

After all was quiet again, we saw a tiny yellow wasplike fly go darting here and there among the ferns as though

searching for something. Her two narrow, gauzy wings beat the air so fast that they seemed to be motionless, but they produced so much power that the fly was able to poise herself in midair and dart from one place to another so rapidly that our eyes could hardly follow her flight. You



A Spider Airing Her Babies

The underground home of this spider is so dark and damp that the thoughtful mother brings her cocoon full of eggs or baby spiders up to the surface of the ground where she whirls it between her hind legs in order to give it a thorough airing and sunning.

(From *Marvels of the Universe*)

have doubtless seen humming birds do the same thing. In a moment this little tiger-fly espied Beauty's supper dangling beneath her web. She darted toward the hanging

fly, but appeared to be very cautious, as though she realized the presence of danger. Satisfied that the way was clear, the tiger-fly launched herself at the swaying bundle and gave it a jab with her sharp stiletto in the end of her curved tail. Away she dashed, as though in fear of her life; but apparently the watching spider had not seen her, for she made no move.

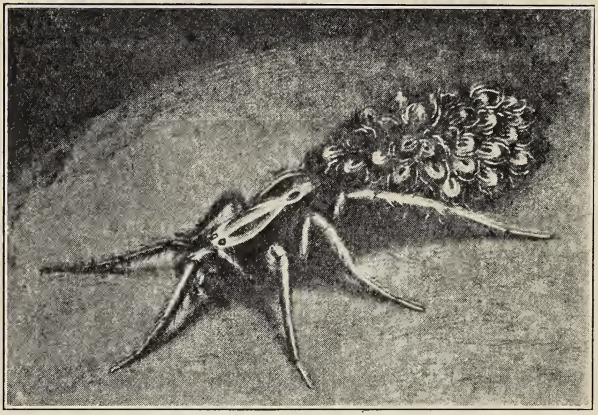
What really happened was this: That tiger-fly stung her eggs into the helpless fly, where they would soon hatch into little maggot babies and find themselves in the midst of their own natural food. Instinct tells these mothers where to place their eggs and how many eggs to put in each victim so that there will be enough food to care for their whole childhood.

Some of the large wasps capture live spiders, especially smaller ones, and carry them off in their jaws to be stung into a stupor and packed into the mud nests of the wasp with her eggs in order that the wasp babies, when they hatch, may feast upon the helpless spiders. We did not see any of those fierce wasps that afternoon; so Spotted Beauty was not molested, but was allowed to live another day.

Carol had been looking around among the ferns to see what other interesting thing she could find. Soon she brought a strange-looking leaf and wanted to know what it meant. On the underside of this leaf was a white, silky disk about as big as Carol's smallest finger nail. It was glued fast to the leaf. I carefully pulled it loose from the leaf, and tore it open along one edge.

Inside was a fluffy mass of loose silk in which were entangled hundreds of baby spiders so tiny that we had to use

a microscope to see their roly-poly bodies and eight squirming legs. Looking like tiny yellow butter balls, they were living on their own fat, but soon they would have to find other food. Then, like cannibals, they would start to eat each other up. Woe betide any baby who does not grow so fast and so big as his brothers and sisters!



A Mother Spider

This spider carries her babies on her back so that she may guard them until they are able to look after themselves.

(From *Marvels of the Universe*)

After this cannibal childhood the few survivors crawl out of their silken tent, climb up on an elevation, and spin a balloon or parachute which wafts them away into somebody's arbor, where they settle down and spin daily their deadly fly traps to help protect their human friends from the pesky flies.

Questions

1. When is the spiders' busy time?
2. How many legs do spiders have?
3. What is peculiar about a spider's eyes?
4. What is the first step in the building of a spider's web?
5. How did Spotted Beauty lay out the frame of her web?
6. How did she put in the spokes?
7. How did she lay down the sticky coil without stepping in it?
8. What did she do with the silk of the discarded scaffold?
9. Describe the spinning machine of this spider.
10. How does she make two kinds of silk?
11. How does she build a suspension bridge across a horizontal space?
12. How do some baby spiders travel about the world?
13. What trick did Spotted Beauty try to play on a fly?
14. Why does not a spider get caught in her own trap?
15. How does the spider bind her victims?
16. Who tried to rob Beauty of her stored-away food?
17. Describe the spider's cradle and the feeding of spider babies.

CHAPTER XVI

THE WOLVES OF THE SEA

I ONCE had a tug-of-war with a shark. If you have ever seen a farmer boy struggling with a pig which he was trying to drive by means of a rope tied to its hind leg, you can picture my struggle with this shark. I had been studying at a seaside biological laboratory on the Atlantic coast and had gone out one morning with some Cape Cod fishermen while they made the rounds of their fish nets. They had found a lively four-foot shark inside one of their nets and had tied the rope of my rowboat around the narrow part of the shark's tail and left me to try to row back to the shore, a mile or so away. When whale fishermen spear a whale with their harpoons, the whale usually races off, dragging the boat after it for miles and miles. I had visions of being hauled out to sea. Some of the time the shark pulled me, and some of the time I pulled the shark. I rowed with all my might, and fortunately the tide set in toward shore; thus I was able at last to drag my struggling shark upon the beach, where I killed him and proceeded to find out all about the anatomy of this queer kind of fish. As a souvenir of this experience, I cut out the jaws with their wicked teeth and had them to show my pupils when I returned to my school.

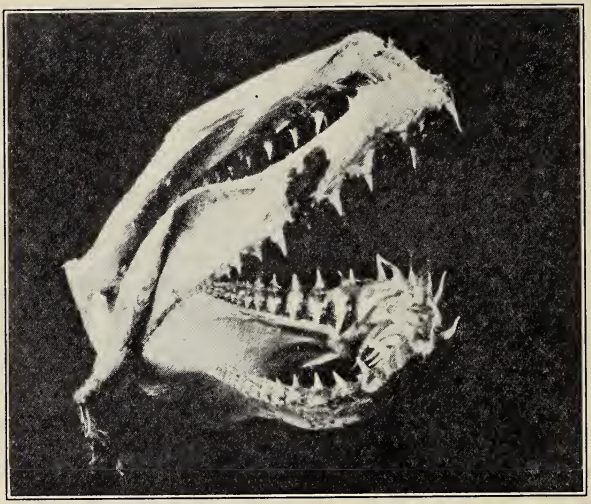
Of the many varieties of these fishes, only a few are big enough to attack man. Blue sharks range in size from fifteen to twenty-five feet in length and are the most common form of man-eating sharks. They abound mostly in

warm tropical seas, but are occasionally found well up along both coasts of North America. The white sharks are the largest of the man-eaters, sometimes reaching a length of thirty-seven feet. They are very powerful and very speedy, their tails being capable of bending in a double curve. They have been known to follow with ease, day after day, the speediest of the great ocean liners, in order to dine on the refuse of the kitchens of these ocean hotels. Woe unto the man who is unfortunate enough to fall overboard!

In a natural history I found the following record of the contents of the stomach of a white shark: a tin can, a number of mutton bones, the hind quarters of a pig, the fore quarters of a bull dog, a large portion of a horse in fragments, and other indistinguishable objects. A basking shark is almost whalelike in size and often crushes a rowboat or sailboat with a blow from its powerful tail. The dogfishes, or sea hounds, are smaller sharks that roam over the oceans in droves like packs of wolves. They follow schools of fish and so cause the fishermen great losses by tearing the nets and eating the captured fish. Some fishermen once captured twenty thousand of these small sharks at one time in a great seine. On some bleak coasts where fuel is scarce these sharks are dried and burned in the stoves. In coast regions where farming is practiced, the sharks are used as fertilizer for the soil. Shark livers are used in the manufacture of oil to serve as a substitute for the more valuable cod-liver oil, which is an effective medicine.

Sharks are the lowest form of true fishes. They differ from the higher fishes in not having a bone in their

bodies, their skeletons being only soft cheeselike cartilage. Instead of flat, horny, overlapping scales, they have in their skins sharp, pointed, teethlike prickles or thorns, deeply imbedded and all pointing backward. These make the shark's skin very tough and hard to cut or bite. In an-



The Jaws of a Shark

The jaws are made of flexible cartilage instead of hard bone. There are seven rows of teeth. The inner rows are situated under the gums and roll upward and outward to get into the line of action as the older ones are worn out or broken off. The teeth are lancelike ivory points with a wide triangular base attachment.

cient times the cabinetmakers used the dried skin of sharks as we use sandpaper to rub the wood smooth. They also used it to cover trunks and boxes that would get rough treatment. The handles of swords and pistols

were covered with it to give a good grip that would not slip. This commercialized shark skin was called shagreen.

The shark does not have delicate fringelike gills under a strong movable plate, as is true of typical fishes, but has a number of slashes through his throat that lead to pouches in which are his gills. The mouth of the shark does not open at the end of the head in a round hoop, as in other fishes, but forms a crescent gash underneath his protruding snout. Such a mouth is believed to fit the shark for digging up and swallowing food found on the ocean bottom, for the shark is a great scavenger. On account of this undershot mouth, the shark finds himself at a great disadvantage when attacking a man swimming at the surface, for he is obliged to turn over in order to bite his victim. This gives the man a chance to dodge the monster.

When you look into the mouth of a shark you shudder to think what it must mean to be bitten by such an array of teeth. He has ivory-white triangular teeth, flattened so that the edges are sharp as razors. The teeth all slope slightly backward into the shark's mouth; this makes it exceedingly hard for a victim to pull loose from the grasp of a shark's teeth. Instead of having two or three sets of teeth replacing each other as one set wears out, as in the higher animals, sharks have seven sets of these terrible teeth in row after row around the gaping mouth. As the front set gets worn or broken, the gums roll outward carrying a second set of teeth into action. The full-grown shark has three or four sets exposed and active at one time.

Another feature of sharks is the tail with its big upper lobe and small lower one instead of the even fan tail of bass

or trout. The fins are all leathery, with a cartilage support instead of the bony spines that prick your fingers when you try to hold a perch in your bare hands. The cartilage in the shark's fins turns into gelatine when cooked. Many people use them for shark's fin soup.

Some sharks provide their eggs with a reddish brown horny capsule to protect them from being eaten by the many fishes and other animals that like eggs for breakfast. Some of these egg cases have their four corners drawn out into curling, wirelike tendrils that cling to the seaweeds. The mother shark thus hangs her cradles around on the bushes. When the baby sharks hatch, they slip out through a crack that appears at just the right time in one end of the capsule. As the mother does not wait to see her babies hatch, they must immediately look out for themselves. These defenseless babies are destroyed in great numbers before they get big and strong enough to be the wolves of the sea.

One branch of the shark race includes a number of families of queer sharks that are flattened out like pancakes, as though some giant had stepped on them. These are called skates and rays. They live on the ocean bottom, lying flat on the sand or mud. The color of their backs so closely resembles that of the ocean bottom that they are practically invisible. When they catch their prey, they crush it down on the bottom with their flat bodies and then tear their victim with the sharklike teeth in their mouths which they can project right out of their heads. Sometimes these odd creatures seem to get playful and amuse themselves by swimming rapidly to the surface, leaping clear of the water, and striking the water with a resounding whack as they fall back.

One of the largest and most hideous of these is called the eagle ray, or sea devil. The pearl fishermen live in dread of this frightful monster, which they believe will throw itself over them, enveloping them as in a great blanket, and then devour them with the chasmlike mouth in the middle of its underside. Since the largest of these devils are twenty feet across, weigh 1250 pounds, and have the strength when harpooned to drag a boat with its crew at great speed for miles, it is no wonder that they are so dreaded.

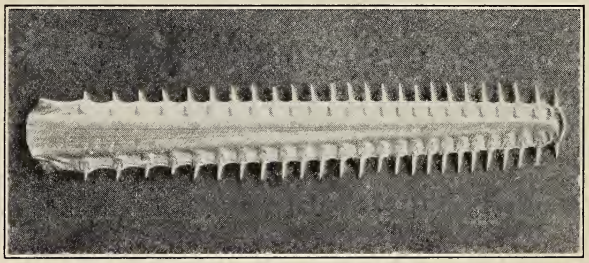
A smaller one of these rays, called the sting ray, has a long whiplike tail with a daggerlike spine near the end which inflicts a very painful and dangerous wound when the ray whips its tail into its victim. While there is no poison in this spine, the slime of the fish's body gets into the wound and causes swelling and severe pain. Blood poisoning is very apt to follow such wounds.

Certain rays, called numb or cramp fishes, torpedoes, or electric rays, are big, fat, rounded creatures with two powerful electric batteries in the back of their heads. These batteries are composed of some five hundred prisms much like honeycomb, with each cell full of clear, jellylike fluid. The electric current from these animal batteries will deflect the needle of the instruments used for measuring electricity, will magnetize a needle and make it behave as a compass, and will decompose certain chemical substances into their elements. If the nerves to these batteries are cut, the fish cannot use his weapon, but if a man stimulates the cut ends of these nerves, the shock is released.

The shock is powerful enough to kill instantly the ray's natural prey, and will severely cramp or numb a man so

that he would drown if he were swimming when attacked by the ray. Scientists think this battery was formerly a muscle, for it is controlled by the same kinds of nerves and must have time to recuperate its strength after working and getting tired.

One of the curiosities of nature is the sawfish. There are two kinds of these strange creatures. One is a shark; the other is a ray. Both have their snouts extended into



THE SNOUT OF A SAWFISH

The sawfish belongs to the shark group of fishes. Its upper jaw is extended forward into a flat blade armed with a double row of sharp daggerlike teeth. The animal kills his prey by dashing forward and rolling halfway over so that his snout slides across the body of his victim like a giant saw.

a long, flat blade with alligatorlike teeth set in sockets along each edge. The jaws of some are six feet long and six inches wide. A sawfish of this size has to be hoisted up into the boat by means of a derrick. These terrible brutes rush headlong at their prey, twisting so that the blade gashes across the body, thus tearing it open or literally sawing the victim in two. They are particularly destructive to certain species of whales.

The depths of the ocean seem like chambers of hor-

rors with these hideous sea devils lurking in wait and pouncing upon the unwary victims. The thought may have come into your mind as it has to many others: Why should there be such awful monsters in this beautiful world? These frightful monsters are one form of scavenger, whose daily duty it is to eat dead bodies and thus prevent them from decaying and fouling the sweet air with offensive odors. When you realize that many kinds of animals produce eggs by the thousands — some even by the millions — it is evident that these creatures would soon fill the sea to the point where there would not be sufficient food or air to sustain them, were it not for these scavengers.

The great races of carnivorous or flesh-eating animals must, by the very nature of their being, prey upon other forms of animals. In order to succeed they must be fierce and powerful enough to overcome their prey and enemies or they cannot survive. They must have sufficient speed and cunning to overtake and seize their victims or they will starve. Their appearance in many cases is such as will make it difficult for either their intended prey or their attacking foe to distinguish them from the surroundings which they often resemble closely. As these creatures are preyed upon by other bloodthirsty animals, it is to their advantage to present to their foes as terrifying an appearance as possible in order that they may save themselves the risk of a combat by scaring their enemy away.

We all enjoy the beautiful creatures of nature; we can also find a real interest in the hideous monsters when we understand the part they play in nature's great drama.

Questions

1. What are two of the largest and commonest of man-eating sharks?
2. How does the basking shark injure people?
3. What uses are made of dog sharks?
4. How do sharks differ from higher forms of fishes?
5. Describe a shark's mouth.
6. What part of a shark is used as food by some people?
7. How do shark mothers protect their eggs and babies?
8. How do the rays capture and eat their prey?
9. How does the sting ray protect itself?
10. How does the torpedo kill its prey or enemy?
11. What are some of the purposes of sea devils?

CHAPTER XVII

SCALY-SKINNED SWIMMERS

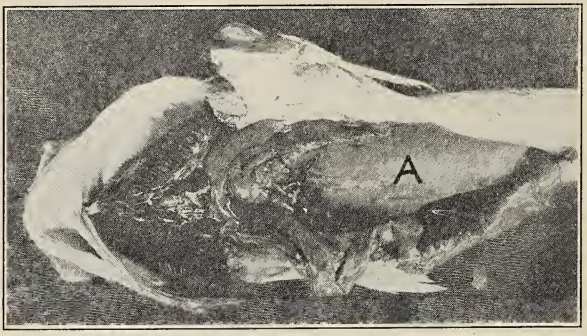
IT is hard for us clumsy landlubbers to appreciate the cool comfort and graceful ease of the fish's life. How he must enjoy the quiet pools and turbulent waves! Fishes have backbones like all the land-dwelling quadrupeds, but they are wonderfully adapted to live their whole lives in the water.

In order that they may move through the water both easily and quickly and also keep themselves afloat with very little effort, fishes are equipped with swimming bladders. These are like balloons inflated with air and suspended just beneath their backbones. By simply squeezing the balloons with the muscles of the sides of their bodies, the fishes are able either to compress or to expand the balloons. In this way they make themselves just enough heavier or lighter than water to rise, sink, or remain perfectly still. Being so light and buoyant, the fishes can move their bodies by the slightest quiver of their fanlike fins. They can also shoot themselves like arrows by a powerful flirt of their tail fins.

If you have ever tried to hold a wet live fish in your hands you have realized how slippery fishes are. All along each side of the fish is a series of glands that pour out through holes in the scales a sort of slippery slime that keeps the body of the fish well greased.

The fish's propellers are thin but powerful fins that may be opened or spread out like fans. The single tail fin is the most powerful propeller and rudder. It drives the fish through the water as quick as a flash, at the same time guiding the boat-shaped body so accurately that the fish seldom misses the fly or worm at which he has aimed.

Under the gland scales on each side is a delicate sense organ that enables the fish to keep his balance perfectly. It also warns him, through vibrations in the water, of the



Internal Organs of a Fish

At A is the large inflated swim bladder. This air sac is attached to the backbone and buoys up the body like the gas bag of a dirigible airship. By compressing this bladder the body will displace less water and so slowly sink down. If allowed to expand, it will displace more water and so cause the fish to rise gradually in the water.

approach of unseen enemies. The big round eyes on opposite sides of the fish's head give him a wide range of vision to see his prey or enemies. The shinglelike, horny scales protect the soft flesh from the attack of enemies and the blows of obstacles encountered.

In order to breathe under water the fishes have delicate fringelike gills through which their red blood is constantly streaming. Hidden under horny plates on the sides of the neck, the gills are bathed by a stream of fresh water which is gulped in through the mouth and driven out through slits in the sides of the throat.

Most fish mothers pour their eggs into the water and leave them with no further care. Most ocean fishes' eggs are transparent and therefore almost invisible. Fishes lay eggs by the thousands, or even millions, in order that a few may escape destruction by innumerable enemies.

Most of the ocean fishes seek the sheltered bays or mouths of rivers at the breeding season. Salmon leave their home in the ocean upon feeling the cold fresh water of the spring freshets. They seek the mountain brooks at the head of the river even though it means a perilous journey of a thousand miles. Salmon leap waterfalls and breast the swift rapids going upstream. They run the gauntlet of strange and cunning enemies. All this they do to provide their babies with the home that salmon babies have been accustomed to for thousands of generations. When the baby fish are grown, they swim down to the ocean.

Fish furnish the human race with nourishing and delicious food. It requires skill and labor to catch them when full grown and ready to use. So wary and agile are fish that they tax man's ingenuity and patience. It was only when man invented great traps by which he could catch whole schools of fish that certain species of them were in danger of being entirely destroyed.

Because of the hard, tedious work and the exposure to

the icy water and biting winds, the life of fishermen is very exhausting. They sail out to the fishing grounds before daybreak and after the hard work they sail home, sometimes at the risk of their lives from the stormy winds and waves. One of the great fishing grounds is the Grand Banks off the coast of Newfoundland.

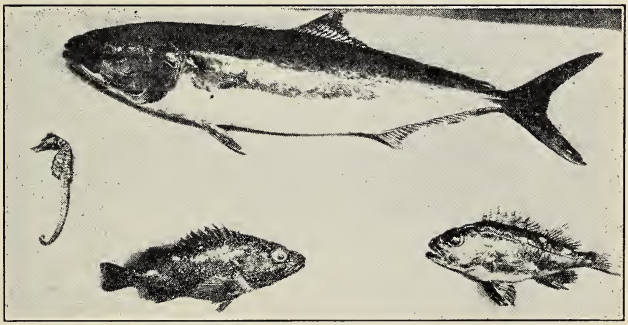
In order to capture fish in sufficient numbers to supply the markets, it was necessary to learn the habits of each kind of fish. Some fishes, like the flounder, halibut, codfish, and catfish, are bottom feeders and can be caught only by tackle that reaches to the bottom of the ocean. Such fish are caught by set lines which are ropes perhaps a mile long attached at each end to a floating buoy. The buoys carry a fluttering flag attached to an upright pole to indicate their position in the water. At intervals along this long rope are fastened short fish lines with several baited hooks scattered along their length. As the fish grovel along the muddy bottom, like so many pigs, they encounter the baited hooks and swallow them.

In the case of the big trout in the Great Lakes the hooks are baited with small fish called bloaters. The fishermen have an ingenious way of hooking these dead bloaters so that they float in a perfectly natural position facing the current. The trout are fooled by the seemingly living prey and gobble them up, hook and all.

The fishermen make the rounds of their set lines once a day and take off the fish as they pull the great rope line over their boat and drop it back again baited for the next day. The trout are usually alive and may fight so vigorously that they have to be hauled on board by means of a gaff, which is a stout pole with a sharp, strong hook on one

end. The fish are cleaned and packed in crushed ice as fast as they are taken off the hooks.

Some fishes roam over the surface waters in great schools and may be caught by gill nets. The mackerel in the ocean and the whitefish in the Great Lakes are taken in great numbers in this way. The gill nets look somewhat like very long tennis nets, except that the mesh is made of very strong linen thread which is practically invisible in the water.



Some Swimmers of the Sea

The cord on the upper side is buoyed up by corks or light cedar wood while the cord on the lower side is held down by lead sinkers. By adjusting the size of the floats and sinkers it is possible to make the long net stand up in the water like a fence without any posts.

For mackerel the net fence is floated along the surface of the ocean, but for salmon, trout, and whitefish it is made to stand up on the bottom in not very deep water near shore. The ends are fastened to floating buoys

marked by flags in order that they may be found by their owners.

As the fishes roam about in search of food, they run into these invisible fences strung across their pathway. The fishes stick their pointed noses into the meshes of the invisible cobwebby fence and feel the delicate threads tickling behind their gill covers. The mesh is too small for them to squeeze through head first and too strong for them to break. If they attempt to back out of the snare the threads of the mesh hook around the platelike covers of the gills, and cannot be dislodged.

Since the net fence is not fastened to posts, it sways back and forth as the fish plunge forward and back, but it holds them relentlessly in its elastic power. No bait is needed, for the net fence is strung across the pathway where these fishes are accustomed to pass.

The next morning the fishermen return and pull the long net up and over their boat. As it is drawn up from the blue depths of lake or ocean it looks like a silver ribbon, for it is stuck nearly full of beautiful live silvery fishes dangling by their necks from the meshes. The men deftly slip the threads over the gill covers and drop the fish into boxes. The fish are cleaned and iced while the men are sailing home.

Herring are caught in enormous numbers both in the Great Lakes and along the shores of the Atlantic Ocean by ingenious nets called pound nets. A heavy cord fence is fastened to strong poles driven into the bottom of lake or ocean and run from the shore out several hundred feet at right angles to the shore until it reaches the jumping-

off place where the water rapidly drops from twenty feet to a depth of one hundred feet.

At the end of this net fence, which reaches from the bottom to the top of the water, a heart-shaped trap is set. Directly beyond the end of the fence is a large net bag perhaps twenty feet square at the top and dipping down some twenty feet. It is fastened to four posts driven firmly into the bottom of the lake or ocean. A funnel-shaped net is set into the side of the bag directly in front of the fence and its inner end is held in the middle of the bag by means of guy ropes. There are net fences running from the two nearest corners of the bag back toward the shore and parallel to the fence that ran out from the shore; thus the fish is guided between these converging fences into the mouth of the funnel.

When once they swim through the funnel into the big net bag, the fish travel round and round the bag looking for a means of escape. They never have sense enough to go back to the middle of the bag and swim out through the funnel.

When the fishermen come out to their nets the next morning, they often find them filled with fish. After closing the funnel they gradually pull up the bottom of the great bag and scoop out the fish by means of dip nets. I have seen two fishermen fill their twenty-foot sailboat full to the gunwales, about sixty barrels of herring at one haul.

Then they sail back to their wharf where they shovel the dead fish into bins in the fish house. Dozens of men and boys spend the rest of the day deftly splitting the fish open, scraping out the inside organs and cutting off the

heads. These men are very skillful and so adept in performing the operation on a fish that the four or five movements needed are done so quickly it looks like a single motion.

The salmon make a run up the rivers from the ocean at the thawing of ice in the spring in order to lay their eggs in the mountain headwaters. Because of this blind rush into the rivers it is very easy for the fishermen to capture them. Some fishermen spread gill nets in front of the mouths of the rivers or in the lower reaches of the river. The Indians used to stand on the rocks near the waterfalls and spear the fish as they struggled blindly up the stream. Wild bears used to wade into the shallower streams and pull the fishes out upon the shores to devour them.

In the Columbia River the fishermen built queer water wheels over the rapids, so arranged that the rushing water kept the wheel revolving day and night. Instead of paddle wheels similar to those of a mill water wheel, they built net baskets somewhat like the cages on the Ferris wheels at our city parks. As these net baskets dipped into the stream and then were carried up by the wheel, they scooped up the fish from the water. The water fell through the net and the fish were dumped automatically into a chute at one side of the wheel that led into a big barge or flat boat. These traps worked automatically day and night without expense or labor and nearly exterminated the noble salmon.

Along these salmon rivers have also been built gigantic canneries where splendid, edible fish are seized by another kind of wheel full of knives which split open the fish, clean it, cut off the head, and chop the body into pieces

just the size to fit into tin cans. Endless chains carry these cans through the machines that solder the lids on, into the tanks of boiling water where the salmon is cooked in the tins, and finally through the machines that paste pretty colored labels on the cans.

These are just a few of the ways in which our markets are kept supplied daily with all kinds of fresh, smoked, and canned fish to help feed the millions of men that must live at the expense of plant and animal life.

Questions

1. How do fish rise or sink in the water?
2. Give a reason for the shape of the fish.
3. How does a fish steer himself through the water?
4. What is the use of scales on a fish?
5. How do fish breathe?
6. How do they care for their babies?
7. How is the codfish caught?
8. How are mackerel caught?
9. What are pound nets?
10. How are salmon caught?

CHAPTER XVIII

PARADISE FISHES

ABOUT the most interesting pets I ever owned were a pair of paradise fishes whose native home was the warm, shallow waters in the rice fields of China. Since they were called paradise fishes, I thought it appropriate to name my pets Adam and Eve. Though they were full-grown, they were not as long as my little finger, and their home while they lived with me was a little aquarium that held only a gallon of water. I planted some green water plants in each corner of their miniature Garden of Eden and covered the floor with pretty pebbles and seashells.

The paradise fishes are as beautiful as butterflies, with banded green-gold bodies and large fanlike fins bordered with two shades of blue. Adam had much larger fins and more brilliant coloring than Eve, just as some male birds are prettier than their mates. Their colors changed very rapidly with changes in their moods, much as a person's face does in blushing from confusion or in growing pale from fright. Adam's color became most intense while he was making love to Eve.

My little paradise fishes seemed to be more intelligent than goldfishes, for they soon learned to come to the front of the tank to meet me, to follow me around the glass sides of their home, bending their heads this way and that in order to watch me, and even to jump out of the water to snatch their food from my fingers held above the surface.

During the first night of their abode in my house Adam nearly committed suicide, and it was only by luck that I arrived on the scene in time to save his life. During his playful darting about in the water he must have leaped out of the aquarium upon the floor, for I found him lying quite stiff and dry and seemingly dead. Although I supposed him to be dead, I dropped him back into the water, thinking that I would bury him later. Imagine my surprise and delight upon my return in a few minutes to find him feebly raising and lowering his gill covers in an effort to breathe. He soon recovered completely and swam around as vigorously as though nothing had happened.

This accident taught me a valuable lesson. I immediately put a glass cover over the aquarium to prevent any more such escapades. You might think that the fishes would then suffocate, but they do not so long as there are green plants growing in the water. These take the bad air breathed out by the fishes and, after removing for their own food the carbon part of this air, pour back, through tiny holes in the leaves, bubbles of pure oxygen. This oxygen is breathed in by the red fringed gills inside the fish's cheeks; thus the paradise fishes lived comfortably inside their sealed-up tank.

Puzzled by what I had seen happen to Adam, I went to the library to see if I could find an explanation of why Adam had not died on the floor as any ordinary fish would have done. It seems that his family have little pouches inside their cheeks right above their gills, and that they can fill these with air enough to last them for some time when they cannot use their gills. This reminds one of the whale which, in a similar way, fills its lungs with air to

keep alive while it is out of air and under water. Paradise fishes have developed these because the water in the rice fields gets so stagnant that they have difficulty in breathing it with their gills. They therefore come to the top and gulp bubbles of air into their cheek pouches to help them along until the water gets freshened by breezes or by the work of the green plants. Thus Adam used this family device to keep himself alive until I happened to come along and rescue him in the nick of time.

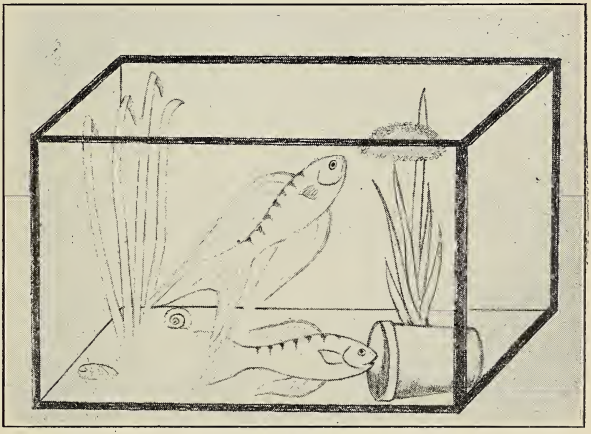
There is a distant cousin of Adam who has these same air-breathing pouches so well developed that he can breathe out of water long enough to make little journeys along the shore after food. He even climbs up the sloping trunks of trees in search of insects. This is called the climbing perch.

As the paradise fishes naturally lived on little insects and other small animals in the stagnant water of the rice fields, I fed them on minced angle worms, on ant eggs, which are really ant cocoons, and on mosquito wigglers and other insect larvae that abound in stagnant pools in any neighborhood. Dealers in pets, I found, sell a specially prepared animal food for the various kinds of tropical fishes now available as aquarium pets.

One morning when I came into my dining room, where the aquarium was kept, I discovered Adam busily blowing bubbles in a little space between some floating water weeds at the top of his aquarium home. He already had a mass of bubbly froth as big and flat as a dollar. He kept at it all day until he had a pancake mass of bubbles as big as a small saucer. Then he began coaxing Eve to come to see what he had made. He became very bright colored,

spread his fins and tail to their full size, and cavorted round and round Eve as he gradually led her over to his little bower.

This was really a nest that Adam had built for Eve, and when she finally swam beneath the fairy canopy she be-



PARADISE FISHES

Adam is shown guarding his nest while Eve is ready to retreat into her flower pot in case Adam attacks her. The nest is made of air bubbles held together by sticky saliva from Adam's mouth.

gan laying her eggs. These floated upward one by one, like tiny balloons escaping from children, and became stuck fast to the under side of the nest.

When all the eggs were laid and safely stowed away in the floating nest, Adam began acting in a most remarkable manner, for, seemingly in a rage, he began driving Eve away, dashing himself against her, even tearing her fins

in his fury, so that she was forced to take refuge in a small empty flower pot which I had placed there for that purpose. Then Adam returned to his nest and stood guard beneath it, swimming back and forth, watching for intruders, and even dashing at my finger when I poked it toward him.

For several days, without even leaving to get food, Adam kept his tireless watch beneath his precious babies, for the eggs had soon hatched into tiny wigglers. Occasionally a restless baby would fall down out of its cradle, whereupon the watchful father would dart out and catch it in his mouth. Much to my relief, instead of swallowing it, he would swim back under the nest, give a little puff, and up would float the tiny baby to land once more in its bubble cradle.

After about a week, during which Adam was kept very busy rescuing babies falling out of their cradle, the nest broke up, and down came tumbling the several hundred wiggling babies, now developed into perfect little fishes just visible to the naked eye. Again the father's mood changed, and if his human keeper had not stepped in and removed him from the aquarium, he would have disowned his children and gobbled them up for his dinner. So I removed both of the parents and left the little family of orphans to play hide and seek among the pretty water weeds.

What did I feed these tiny babies? Well, being baby fishes, they enjoyed eating water fleas, which are cousins of crabs and lobsters but only as big as the heads of the smallest pins. You have heard of South Sea Island cannibals who are reputed to have dined on missionaries. These young paradise fishes soon began to reveal the na-

ture of cannibals by gobbling up any unfortunate brother or sister who did not happen to grow as fast and as big as themselves.

While our little flock was slowly dwindling in numbers, the few survivors were waxing larger and more beautiful, and the young males soon began to grow their larger and more beautiful fins and tails, just as human big brothers strut around with a moustache or beard.

In spite of the murderous behavior of Adam and the cannibal actions of his children, do you not think that the paradise fishes proved to be very enjoyable pets?

Questions

1. Where is the native home of the paradise fishes?
2. In what ways were the paradise fishes like butterflies?
3. Why can paradise fishes live out of water longer than most fishes?
4. Why was it necessary for these fishes to develop this habit?
5. What is the habit of the climbing perch?
6. What would you feed paradise fish?
7. Describe the building of the nest.
8. How were the eggs placed in the nest?
9. What care was given to the baby fishes?
10. What was the strange behavior of the young paradise fishes?

CHAPTER XIX

THE CHAMPION BROAD JUMPER

HOW far can you jump in a broad jump from a standstill?" I asked a husky six-foot college athlete, and he answered me by jumping nine feet. That was a good jump, but he wouldn't have a ghost of a chance to beat my champion, the frog. Although my champion measures only seven inches from head to tail, he makes a leap that carries him five feet high and lands him ten feet away. Instead of jumping one and one-half times his own length, my broad jumper leaped seventeen times his length without counting the five-foot flight through the air.

If you will catch a frog and straighten out his legs, you will surely exclaim, "What long legs he has! No wonder he can leap!" Just feel his calves and thighs and see what batteries of muscle engines are built on his legs. Drop the frog down on the ground and see how this ages-old family of broad jumpers has perfected the starting system that we human athletes flatter ourselves is our invention. Listen to the referee in a college track meet. "On your mark! Get set! Go!" But not one of his men can beat the frog in his getaway! The frog's legs are doubled up in three sections like a jackknife, the long toes are flattened close to the ground, with their tips bent down in a ground-gripping hold, and the arms are bowed out to elevate his head at just the right angle to aim him for his goal.

At the word "Go", Mr. Leap Frog seems to explode dynamite in his muscle engines. His long jointed levers straighten out to full length in the flick of an eyelash, and the solid earth gives back in one great rebound every ounce of energy expended by those legs and hurls the slip-

A Frog — Front View

This view shows the peculiar bow-legged, pigeon-toed posture of the frog's front legs, and the way the hind legs are folded under the body ready to spring. The front legs raise the head and aim the body. By being bowed, they keep out of the way of the hind legs as the body shoots forward.

pery, double-jointed body like an arrow shot from a cross-bow. Man comes nearest to making such a jump when he makes a leap on a pair of Norwegian skiis in sliding down a mountain.

We frequently see pictures of boys and girls doing the graceful act of making a "swan dive." To the beginner it

seems impossible that the diver can, in the last few seconds before striking the water, jackknife the body into an exactly opposite position and bend head and arms down as they cut the water like an arrow. Here again we find the frog leading the way. If your eyes are keen enough to follow his wonderfully rapid movements, you will see his arms bend forward to catch the weight of his body in landing, as upon a springboard. His long legs, stretched out behind in flight, will be doubled up under him ready for instant rebound into the next leap as they strike the ground.

What swimmer would long be satisfied to paddle "dog-fashion"? Do we not all strive to learn how to swim "frog-wise"? See how the frog uses his arms as short paddles, with the stroke ending close to the body, and how the two powerful hind legs with their big, webbed paddle feet are drawn forward together and then shot straight back with webs spread out to drive the body ahead with terrific force. Drop a frog in a tank of water where you can look down on top of him as he swims and you will get a very fine demonstration lesson in swimming. He even keeps his head and shoulders deep down in the water with just his nostrils above the surface.

How does the frog get the signal "Go" so quickly that he usually lands "ker-plunk" in the pond before you see him at all? Look at those big, wide-open black eyes with their gold rims. Observe how they pop up above his head like a pair of periscopes on a submarine. He can sink beneath the water with nothing visible but those two periscopes and his nostrils. The pupils of his eyes are not round like yours, but widen out sidewise so that they can take in the entire horizon at a glance.

Those shiny plates behind the frog's eyes are eardrums. Because they are so much exposed on the sides of his head, they can hear every little sound you make in stepping on snapping twigs or crunching gravel. Undoubtedly the frog's soft, naked feet, without nails or hoofs of any kind,

A Frog — Top View

This is a different view of the frog. Notice how the length and position of his legs enable him to make his long leaps. The dark discs behind his eyes are his eardrums.

are very sensitive to the jars or vibrations sent through the ground and to any movement of his enemies walking toward him.

Have you ever noticed what a hide-and-seek suit of clothes the frogs and toads wear? The plain green frogs

lie in the scummy water of the frog pond and look just like a patch of scum. The leopard frog, with his pretty black spots on a green skin with a few gold lines for trimming, matches the patches of black mud among green leaves and the stray streaks of golden sunshine. If you will examine a number of frogs, you will see that some are light and green while others are dark and black. By keeping track of some of these individuals as you place them in sunny, weedy places or in muddy spots, you will be surprised to find that the same frog is not the same shade all the time, but changes color to match his surroundings.

Scientists have studied the skin of the frog and discovered that the black spots are caused by groups of cells under the skin that are full of black pigment or grains of black coloring matter. These living cells contract or spread out as they are controlled by nerves leading to each cell. In a very complicated manner the light from the surroundings passes through the eyes or even through the skin to the brain and down to these color cells, causing them to alter the amount of black in the frog to match the ground upon which the frog rests.

Above this layer of pigment cells is another transparent layer of cells containing tiny yellow bodies which shift their positions about. This is called the interference layer, because it interferes with the light as it travels from the color or pigment layer to one's eye. It is like shifting a shutter to let more or less light pass through. Thus black may be made to change to brown or blue. The yellow and blue color effects may produce green. The golden and shiny tints are produced by special cells with a metallic gleam. The tree frogs show the most rapid and striking

color changes. This enables them to hide very effectively by resembling gray bark or green leaf.

Surely you have heard the frog and toad choruses in the lily ponds during the spring and summer months. Did you ever creep up stealthily enough to surprise the singers? Look at that balloon under his jaws. The frog reminds you of a cornet player who puffs out his cheeks until you begin to fear that they are going to explode. All the frog and toad singers are obliged to breathe with the mouths and lips shut tight. We never see one of them "baying at the moon" with mouth wide open like a dog. They breathe by means of a pump or bellows in the throat under the tongue, which you can watch as it pumps air down into the lungs. The nostrils have tiny valves which open and close just like the valves in a water pump. If the mouth should open, the air would escape between the lips instead of being driven down through the windpipe, thus causing the animal to suffocate.

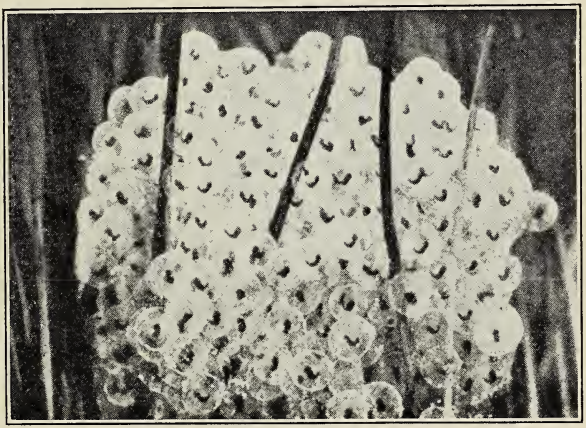
Both the frog and toad have vocal cords which are set vibrating by air rushing in or out of the voice box just as in human beings. In order to enable these animals to sing all night without interfering with their breathing, they have special balloonlike air sacs in the bottom or sides of their throats. These are pumped full of air which works the vocal cords very much as the bag in a bagpipe blows continuously on the reeds of the instrument. The tree frogs have one croaking sac under the chin; the common toad blows up its balloon at the base of its tongue; the frogs have two sacs, one over each shoulder. In some of these frogs the croaking bag is as big as the body of the animal.

The noise is usually a trill or series of chirps, sometimes soft and musical, sometimes harsh like stones grinding together. In the big bullfrog it sounds like the bellowing of a bull and may be heard for a considerable distance. The words "jug-o-rum," if growled in a deep bass voice, will give you a fair idea of the sound. The first time you camp overnight near a bullfrog pond you may hear them.

Have you ever realized that both frog and toad live two entirely different lives — not at the same time, like Dr. Jekyll and Mr. Hyde, but one following the other? At first as a tadpole, the frog or toad is as perfectly fitted for life in the water as any fish. After going through a series of remarkable changes, called a metamorphosis, the adult becomes really and truly a land animal. Because of this double life, all these animals are called amphibians, a name that means *double-lived.*

When spring arrives, the toads all migrate from the gardens into the nearest suitable pond or puddle and the frogs climb up out of their winter sleeping quarters in the mud at the bottom of the swamps. The mothers lay their hundreds — or even thousands — of round ball-like eggs while they crouch just under the water among the weeds and lily pads. The eggs are about the size of a black-headed pin and are black on one side and white on the other. When laid, each egg is enclosed in several transparent layers which swell rapidly after soaking up water and form a slippery, tough, jelly covering. This covering holds the eggs apart, so that each egg can get air for breathing, and glues them together into one rubbery mass so that fishes and other enemies will find it very difficult to suck the eggs, one by one, out of the bunch.

As frog and toad mothers are cold-blooded and cannot brood their eggs as hens do, it is necessary to have some other arrangement to heat the eggs enough so that they will hatch. You know that black clothes are very uncomfortable in the hot sun in summer because black soaks up the heat as a sponge does water. In a similar way, the



FROGS' EGGS

This shows the transparent globular jelly covering of the eggs, and the little tadpoles within already showing head, body, and tail. The black color of the tadpoles absorbs heat from the sunshine.

(From *Marvels of the Universe*)

black of the upper and more buoyant side of each egg absorbs enough heat from the spring sunshine to run the frog's incubator. Just as we cover over our steam pipes with asbestos to prevent the loss of heat through the walls of the pipes, so each egg is covered with a sticky, transparent jelly that holds the sun's heat.

The frog mothers never pay any attention to their children, but they do one thing before they go off and leave their eggs. They glue their bunches of egg masses, each as big as a man's fist, on to sticks or weeds just below the surface of the pond where they will be hard for the enemy to see, but still near the sun's rays. The toad lays her eggs in long single strings of beads held together by a clear strand of jelly. She winds these long streamers in and out among the water weeds. The tiny strands are pretty enough to become strings of pearls for the water fairies.

In a single day, if the weather and the water are warm, you can see the black and white egg ball beginning to change. A little bump bulges out at either end, one for the head and the other for the tail. These grow rapidly, and soon you see inside the glassy ball a tiny black fishlike creature. In a week or two, depending on the weather, the jelly gets soft and slimy, and the tiny tadpole or polliwog bursts its way out of its cradle and perches on the top of the jelly mass where it is nice and warm. For days it just lies there and sleeps as any well-behaved baby should do. It wiggles its tiny tail instead of its toes, for it has no toes yet. It does not eat anything, for its mouth is not yet formed.

After a few more days the little "tad" begins taking little journeys by wiggling his tiny tail. A little sticky pad grows on his chin so that he can fasten himself to the weeds or other handy things. Little feathery gills sprout out of his neck and the tadpole is able to breathe just like a little fish. But this exercise has made him hungry; so he opens his funny little triangular mouth with its black, horny, parrotlike beak. He browses like a sheep upon the

STAGES IN THE DEVELOPMENT OF TADPOLES

At first the little tadpoles have gills on the outside of the neck. These soon disappear and are replaced by gills inside the neck. The head and body grow into a black oval mass and the tail is surrounded by a thin fin. After considerable growth, the hind legs sprout at each side of the base of the tail. About this time the lungs begin to work; so the gills shrivel up and the tadpole has to come to the surface to get air. As soon as the hind legs grow big enough to propel the tadpole, the tail fin begins to shrink. When the front legs appear, the tadpole is about ready to become a frog.

(Adapted from *Marvels of the Universe*)

green slimy moss that grows all over the weeds and mud. In order to digest such bulky green stuff, his intestine is so long that it has to be coiled round and round, showing through the transparent skin like a wound-up watch spring. Thus for weeks, or even months, the tadpole lives the life of a true fish, and would be helpless out of water.

Later in the summer we see signs of the changing of our little "fish" into a frog or toad. On either side of the base of the tail we see a tiny hind leg sprouting. After a few weeks more these have grown big enough to begin helping the tail in its swimming work. Soon a front leg pokes its way through a breathing hole in the neck, while the right one somewhat later bursts its way right through the skin. The lungs have been growing and are now ready to begin taking over gradually the breathing work, so far done by the gills. You will see the older tadpoles coming to the surface and gulping down a few bubbles of air. The mouth gradually widens at the corners, and a flapper tongue replaces the horny beak. This tongue, fastened only by its front end, will be snapped out against flies and bugs which stick to its gluey tip and are flipped down the frog's throat before they can say "ouch."

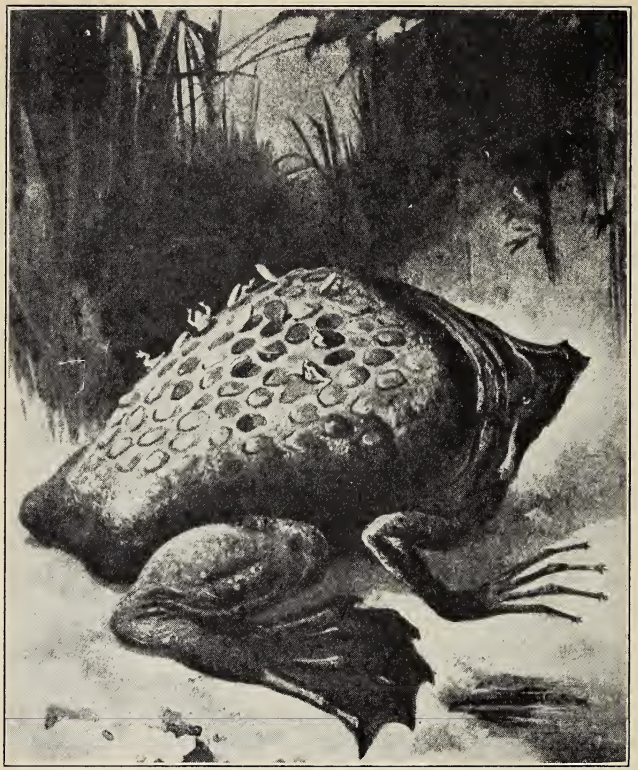
As the diet changes from grass to bug meat, the intestine stops growing until it is no longer a coiled tube, but a nearly straight short tube, with the stomach more like that of a cat. Now we have our black swimming tadpole changed into a spotted green frog with fly-trap mouth and meat diet, with two pairs of legs for leaping over dry ground, and a pair of air-bag lungs for breathing in the air when not under water.

But what became of that tadpole's big swimming tail? Did you never notice little baby frogs or toads hopping about on the edge of the pond? Surely you noticed that some of them had stubby little tails between their legs. When the little frog is about ready to forsake the water for the land, the tissues of his tail begin to dissolve and are carried away in the blood. The tail seems to shrink and grow smaller and shorter while these materials are being sent in to be used in building the new body. Bigger bones and stronger muscles are needed to carry the weight of the frog out in the air where the water's buoyant power can no longer help to make his body lighter.

There are some queer frogs and toads in the tropics. In one locality the tree frogs cannot find ponds for their babies; so they have learned to lay their eggs in the dewdrops that collect between the base of the leaves and the stem of the plant. The tadpoles hurry up their development and pass through all their changes while inside their transparent cases and hatch out as regular little frogs.

Mr. Darwin found a male toad in Chile, South America, that took the eggs from the female as fast as she laid them and stored them away in cheek pouches opening into his mouth by trapdoors on either side of his tongue. When the baby frogs were through all their changes, they climbed up through the trapdoors and jumped outdoors through their daddy's open mouth. None of these babies ever lived a day in the water as tadpoles.

In France another kind of male toad stands by while his wife lays her jelly strings of eggs. He then steps into the sticky mass and manages to get the strings all wound over his hind legs and hips. He guards these eggs while they



SURINAM TOAD

When the female lays her eggs, her mate pushes them up into her back. The skin at that time becomes soft and spongy; so the eggs sink into the skin which grows over them forming a pocket for each with a trapdoor lid. When the little toads have completed their tadpole existence, they push up the lids and escape.

(From *Marvels of the Universe*)

are developing, carrying them into the warm, well-aired spots in the pond until the babies have all hatched.

Perhaps the strangest case of all is that of the Surinam toad of South America. The mother toad, as she lays her eggs, manages to push them part way up on her back. The watchful father toad stands by and pushes the eggs farther up over her back and shoulders, pressing them one by one down into the soft, spongy skin of the mother's back, where they sink in like raisins into dough. The skin gradually grows over each egg in its pit and forms a lid much like that of a trapdoor spider's nest. The fifty to one hundred eggs go through the complete development of all their tadpole stages inside these pockets on their mother's back. At the end of eighty-two days the lids begin popping up, and one by one the tiny toads come climbing out like jack-in-the-boxes.

After resting a few days on their mother's back they hop off, wagging a last farewell, for never will they recognize her among the thousands of toads they may chance to meet in their wanderings. As soon as her family has departed the mother changes her clothes by shedding her skin, losing all the tattered pockets in her old garment. Once more we are moved to repeat: "Truth is stranger than fiction."

Questions

1. How does a frog compare with a man in broad jumping?
2. What makes the frog so quick and so powerful?
3. What is the frog fashion of swimming?
4. How does the frog play hide-and-seek with his clothes?
5. How does the frog change his color?

6. How do frogs and toads make their music?
7. How does a frog sing without opening his mouth?
8. How do frog's eggs get heated enough to hatch?
9. For what two different lives are frogs fitted?
10. What is a metamorphosis?
11. What are some of the strange ways these animals have of raising their children?

CHAPTER XX

THE HORNED TOAD AND HIS COUSINS

ONE of the curios that my tourist friends used to bring back from the West was the horned toad. When I came to live in California I began to keep watch for that odd little creature, for I was curious to see one alive and at home. One hot summer day in a sandy back lot I caught a glimpse of something slithering across the sand like a flash. Suddenly it stopped, and there stood my little toad with his horned head cocked on one side and his narrow slit-eyes watching me. He seemed to be saying, "Here I am. Catch me if you can."

Well, I did, but I certainly had to scramble around in lively fashion. If he had been in a clear space, I doubt if I could have captured him. He struggled for a few moments and then lay perfectly quiet in my hand. He did not try to bite me. He seemed to cave in until I wondered if he had any insides. I have read that some horned toads blow themselves up to be as big and forbidding-looking as possible.

I have been watching all the horned toads I have seen since that first one to try to discover one shooting a stream of blood out of its eyes. Raymond Lee Ditmars says that he had examined hundreds of these animals without seeing that queer action and had about made up his mind that it was a notion and not a fact, when one day he received a present of a big fat specimen of Mexican horned toad. He photographed the creature until the little beast

became quite angry. "It finally threw the head slightly upward; the neck became rigid; the eyes bulged from the sockets; there was a distinct sound like forcing air by pressing the tongue against the roof of the mouth. This gasping sound was accompanied by a jet of blood at high pressure. It hit the wall four feet away. The force gradu-

A Horned Toad

The right-hand picture shows the alert attitude of the horned toad with his head tilted slightly so as to watch an enemy and be ready to scramble away. The left-hand picture shows the pebbly coat of scales all over the under side of the body. The legs are very short and the toes are curved and armed with claws.

ally diminished as noted by a course of drops down the wall and along the floor. The stream seemed to be as fine as a horse hair and to issue from the eyelid which was momentarily smaller. There were 103 spots of blood, each about ⅛ inch in diameter."

I made a cage with mosquito-wire walls and kept a num-

ber of horned toads I had picked up on the ranch. Some were nearly as big as the palm of my hand, while the smallest ones were smaller than the last joint of my thumb. They climbed up the wire walls very easily with their four short legs armed with sharp toe nails. But most of the day and all of the night they burrowed out of sight in the dry sand that covered the bottom of the cage.

It was comical to see a toad dig sand with the front paw and then the hind paw, first one side and then the other. He used his flattened triangular head with its backward projecting fringe of rose-colored spines as a shovel. Sticking his nose into the sand, he plowed his way headfirst under the sand, his flattened sides with the fringes of spines scuttling under the sand as it slid back over his head. Being cold-blooded, the toad does not need to breathe very much except while he is in action. Thus he can be buried for hours, without distress, several inches in the sand.

The horned toad feeds on insects which he captures by stealthily crawling close to his victim and then shooting him with his sticky tongue. In captivity the horned toads thrive upon meal worms, which are grubs in the bodies of certain beetles. Upon examining the dried pellet of waste from the animal, I found it to consist of dozens of dried empty insect shells all broken and packed together in a mass. I could see the round heads and big compound eyes of the insects. In another pellet I found a mass of dried red ants.

I found one big toad that had met its death in some way and I opened it. There were in it ten round yellow egg yolks about the size of peas.

I have been hoping to run across a mother with her brood of babies, for the horned toads give birth to fully developed babies instead of laying white-shelled eggs as most reptiles do.

If you look closely at the top of the toad's head, just in front of the horns, you will find a group of little beadlike scales. You may be interested to know that the central one is believed to be the relic of a third eye that used to enable the ancestor of this toad to see behind himself. One type of lizard, living in New Zealand, has such an eye in that same position.

We have been calling our pets "horned toads," but they really are not toads at all and do not even belong to the same race of animals. Our common toads do not have scales covering their skin or toe nails on their feet. True toads hatch out as tadpoles and spend the first part of their lives in the water. Our little pets are really horned lizards, even if they are not slender, long-tailed creatures like ordinary lizards. Our horned lizards live in the desert places, and their skin and scales are colored to match closely the sand and gravel. They do not have much ability to change their color like their celebrated cousins, the chameleons.

You have probably seen these graceful green lizards, the chameleons, on sale as pets in bird stores. Most people have supposed that the color of one of these creatures automatically changes to match the object it is near or on. Mr. Ditmars discovered that its color depended upon its feelings. When comfortable and happy it was a golden-brown hue, but when scared or chilly it turned green. When sleeping or fighting, it invariably turned green. It

would seem that the animals are frequently aided by the resemblance of their colors to their surroundings, but this resemblance is not such a direct relationship as it is in the case of the tree frogs.

The African chameleon has a much more pronounced color change than our American chameleon. It is a very

A Chameleon

The chameleon is a lizard that has the power to change its color according to its surroundings or its feelings. Its tongue is a slender, muscular rod capable of being extended the length of its body. The outer end branches into two sticky flaps that wrap around insects.

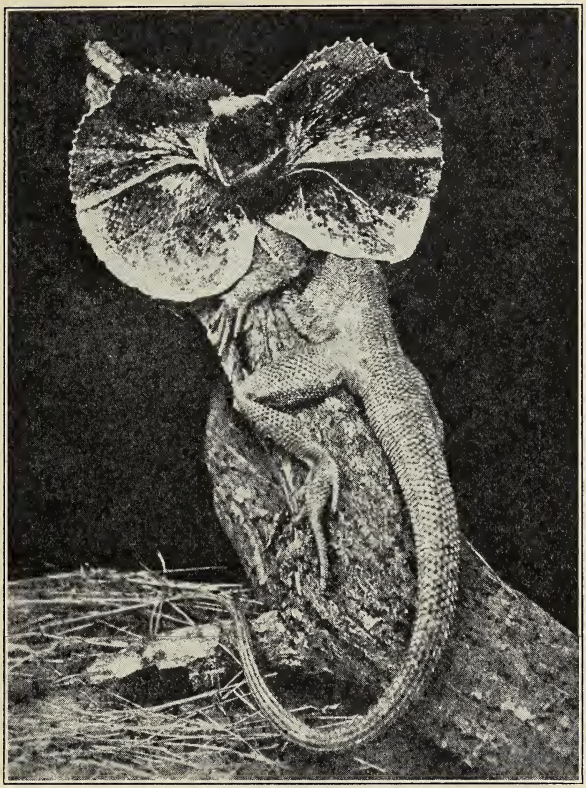
(From *Marvels of the Universe*)

grotesque creature with a monkey tail that winds its tip around a twig. The hands and feet have their fingers and toes divided into right and left groups so that they can clasp the limb lengthwise as the animal walks along. The bulging pop eyes have the most grotesque way of looking

in different directions. One eye may remain fixed upon a fly at the right, while the left eye rolls around hunting up and down for a bug on the left side.

This queer animal has a tongue that he can shoot out seven inches, or the length of his whole body. It is tubular in shape, with a sticky knob or flap at the outer end. When a chameleon creeps up toward a fly, perhaps fooling the fly by looking with one eye in some other direction, he suddenly shoots out that wonderful tongue and the fly disappears like a flash. If you will imagine an air popgun with the cord made of elastic so that the cork would be jerked back into the gun as soon as shot, you will have a good idea of this fly shooter.

As all lizards are preyed upon by many enemies who like their white flesh, they have been provided with a queer kind of protection besides their scales, their color changes, and their wonderful agility. Their tails are often longer than their bodies and are undoubtedly a great help in steering the animal in its rapid locomotion, which is almost like flying. Their tails also make a very convenient handle for those who try to capture them. I still recall my feeling of horror as well as surprise when I once found a wiggling tail in my hand when I thought I had caught the lizard. The little animal forfeits his beautiful tail rather than his life; he snaps it off, leaving it as a souvenir in your hand while he scampers away, very much bob-tailed, but happy to have escaped. This little trick he can perform because there is a cartilage partition through one of the vertebrae near the base of the tail. A few weeks after the animal has lost its tail, this pad grows a fairly respectable new tail, though it is without regular vertebrae.



THE FRILLED LIZARD

This queer lizard lives in Australia. When disturbed, it faces its enemy, spreads out its frilled collar, and, opening its yellow mouth, hisses and shows its teeth.

(From *Marvels of the Universe*)

There are some European lizards that have fanlike expansions of the skin on their necks that can be opened and closed like an umbrella. As these lizards leap long distances from tree to tree, these serve as parachutes that help the animal to keep afloat in the air during long leaps.

Very few lizards are poisonous, but there is one poisonous lizard commonly exhibited in museums and zoos. This is the lizard from Arizona and New Mexico called Gila monster. This sluggish, repulsive beast is about eighteen inches long, is black and salmon-pink in color, and has a blunt-nosed head with black jaws and throat. His four weak legs are far apart and unable to carry the animal's body. He crawls slowly along on his belly. His tail is rather short and fat. The whole body is covered with round pebbly scales crowded close together. The beast does not have hinged fangs like venomous snakes, but it has grooved teeth through which poison may trickle into a wound. The monster does not inject its poison as deeply and surely as the snake. Its bite is much more venomous if given when the monster lies on his back.

While the Gila monster is sluggish in captivity, it is much like the alligator in its surprising agility when encountered in its wild haunts. When disturbed it hisses, opens its hideous black-lined mouth, and snaps viciously from side to side. It hangs on with the grip of a bull dog. Mr. Ditmars demonstrated its grip by dangling a strap in front of an infuriated monster who snapped his jaws into the strap and hung there ten minutes while suspended above the ground.

In Europe there are some queer little lizards called

geckos that have a suction pad on the tip of each toe which enables them to cling to the window pane or ceiling. They live in the quiet churchyards and clamber over the stone fences and stone churches. There are also many species of lizards that are quite at home in the water.

All lizards on the earth today are comparatively small creatures, but there was a time when this earth was in-

Gila Monsters

This is the only lizard that has poison glands like a rattlesnake. You can see the bulging of these glands behind the eyes. The animal seizes his victim with a bulldog grip. As his teeth close, the poison sacs are compressed, and the poison is poured into the wound.

habited by enormous lizards of frightful appearance and terrible ferocity. Some stood thirty feet tall and some were over one hundred feet long. Their bones have been found in the rocks of the Rocky Mountains. Sometime you will find it interesting to read about these great dinosaurs.

Questions

1. In what kind of places does the horned toad like to live?
2. What strange thing do horned toads sometimes do?
3. How does the animal bury itself under the sand?
4. What do horned toads eat?
5. Why is the horned toad really a lizard?
6. What seems to make the toad change its color?
7. How does the chameleon hold on to the branch?
8. What is the peculiar behavior of the chameleon's eyes?
9. What can a lizard do with his tail?
10. What helps some lizards to leap from tree to tree?
11. How could you recognize the poisonous lizard?
12. What kinds of lizards lived on the earth long ago?

CHAPTER XXI

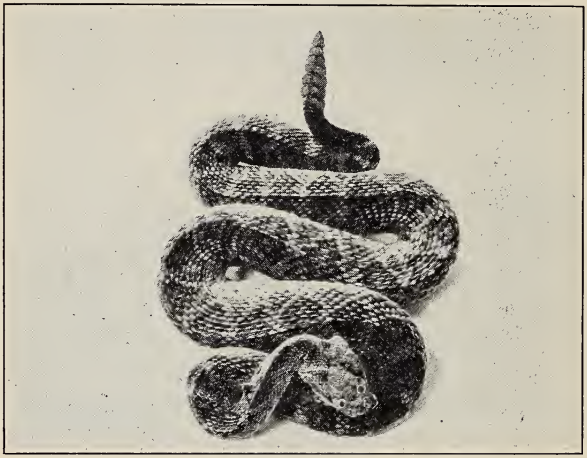
RATTLESNAKES

ARE all the big rattlesnakes gone? Recently the press reported that the largest rattlesnake ever seen in Oregon was killed near Canyonville. The reptile measured five feet in length and was more than ten inches around and three inches in thickness. There were twenty-nine rattles and one button. Was that really a big rattlesnake?

There are fifteen different species of rattlers in the United States; that found in Oregon is the Pacific rattlesnake. We are told that the average full-grown specimen is thirty-four inches long and one and one-fourth inches in diameter, but this species is one of the smaller ones. According to these figures the Oregon specimen would be by far the largest snake of its species ever found.

What shall we say about the twenty-nine rattles? As most people assume that each rattle indicates a year, that would make this a very old snake. Mr. Ditmars, the Curator of Reptiles in the New York Zoölogical Park, has kept and raised nearly every species of snake found in the United States. He found that the baby snake is born with the button, and in about two months acquires the first rattle. In all the years afterward, the snake adds another ring to its rattle every time it sheds its skin, which is usually three and sometimes four times each year.

It seems that about ten rings make the most effective rattle and that any beyond that number usually get snapped off by the violent shaking of the rattle, or worn off by striking various objects. Thus it is very unreasonable to expect to find so many rings. If this snake really



A Rattlesnake

When attacking, the rattlesnake coils itself into loops and then thrusts forward its death-dealing head by suddenly extending its body. The bulges at the back of the head indicate the poison sacs which are modified salivary glands containing a poison secretion powerful enough to kill most animals that molest the snakes.

had twenty-nine rings and had lost none, it would be about nine years old.

Why does the rattlesnake alone of all kinds of snakes have a rattle on its tail? Why should this venomous snake betray his location by sounding a noisy rattle?

I suppose you think that this poisonous reptile is always on the warpath, striking death right and left. After a careful study of the rattler both in captivity and in the wilds, scientists say that the rattlesnake is a timid, peace-loving creature whose greatest wish is to be left alone. Why does such a timid creature carry such a deadly weapon? For two reasons. In the first place, he uses his poison to kill his necessary food without running the risk of a long struggle. In the second place, he must be able to protect his life from any enemies that might attack him.

Suppose he should waste his precious poison in biting every creature he could reach, whether he was hungry or not and whether the animal intended to molest him or not. Would he not be like a man in a dangerous country who shot off his limited ammunition at every rock or tree that looked like an enemy? The snake never uses his poison unless he thinks he is obliged to do so to get food or to protect himself. Naturally, since he has many enemies, he has a hair-trigger disposition. At the slightest sign of approaching danger he throws himself into a gracefully symmetrical coil; his body becomes inflated and his neck arches into an oblique bow supporting his heart-shaped head, while his tongue with its spread and tremulous tips waves slowly, and the rattle whirs incessantly. That is just a wild creature alert to his danger and ready and able to defend himself from an enemy, no matter how powerful. Stand still and he will quickly uncoil and glide away, as soon as he is convinced he is not going to be attacked. Mr. Ditmars says he has never known a rattlesnake, unprovoked, to attack a man. He has many times in his trips over the western plains laid his blankets on the ground

and gone calmly to sleep even when he knew that the region was the home of rattlers.

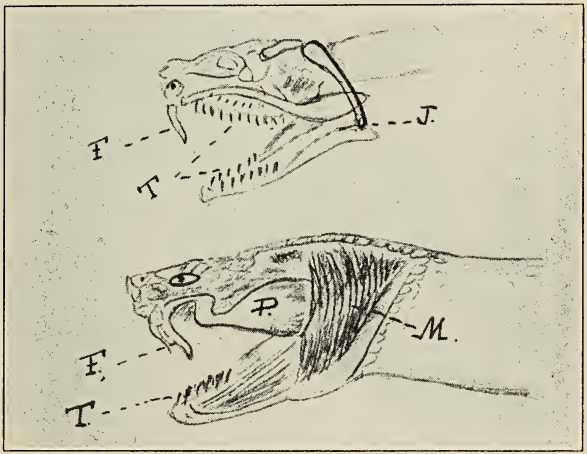
Why does the snake sound his rattle? He does it to protect himself from a needless attack and to save his precious life-saving poison from being shot into every suspected neighbor.

You should be careful not to walk too quickly toward a sleeping rattler or place your foot near the snake before he has a chance to warn you of his previous possession of that sunny, warm spot. Just give him a fair chance to keep out of your way and he will not molest you.

Let us see how the rattlesnake is fitted to live his own life successfully. Those dreaded poison fangs are special teeth in the front of his upper jaw that are hinged so that they can be laid down flat in the roof of his mouth while he is swallowing his food, but bent out at right angles in his wide-open mouth when he strikes them into his prey or foe. Each tooth is perforated by a needlelike tube which opens on the tip of the fang and leads from the poison sac, which is nothing more than a salivary gland whose saliva contains a terrible poison. In case he breaks one of these fangs or wears it out, one of the several reserve fangs hidden back under the skin grows up into the proper position and makes connection with the poison bags.

Circus snake charmers make their pets harmless by extracting the fangs, but they have to keep watch and remove the new ones as soon as they appear. When the snake strikes these fangs into his victim, his lower jaw clamps up so as to force the poison teeth deeply into the flesh. This poison acts only through the blood and so must be hypodermically injected into the blood vessels.

The poison, if swallowed, cannot get into the blood from the stomach and so it does not hurt the snake to swallow his poisoned prey. At any rate the snake is immune to his own kind of poison.



A Snake's Head

The upper diagram shows how the lower jaws are fastened to the skull by movable bones with hinges at J. The regular teeth (T) are small and curved inward so that they can grip their prey and, by means of the hand-over-hand action of the jaws, force the victim down the throat. In the lower diagram, (F) shows fangs which are connected to poison sacs (P) behind the eyes. The muscles (M) on the jaws squeeze the poison sacs and force the poison out.

It has been found that small injections of snake poison in domestic animals cause the white corpuscles of their blood to manufacture a kind of antidote which can be transferred in the serum of the animal's blood to a human

being to save his life from a snake bite. This serum is kept on hand in many places where it is likely to be needed.

How can a snake swallow an animal whole whose body is larger in diameter than his own? Every snake, whether poisonous or not, has very loose-jointed jaws. These jaws have elastic ligaments in the sockets and in the middle of the chin which enable them to be pulled wide apart. The skin of the throat and whole body is as elastic as a rubber tube and can stretch enough to let a big body pass down. All snakes have one row of sharp needlelike teeth curved inward; thus no food once hooked can escape or be withdrawn. If the food has once gotten well hooked, the snake cannot prevent it from going down. One big snake once caught his teeth in the blanket on which his food was thrown and had to swallow the blanket. Two snakes in the zoo once got started on the same rabbit, but on opposite ends. When their lips met in the middle, one of the snakes had to swallow the other because neither could let go or back up. As soon as the snake gets a good hold, his upper and lower jaws keep hitching alternately, the teeth slipping forward and hooking into the flesh again as soon as the jaw starts to draw back. In this hand-over-hand fashion the snake's mouth draws the throat and body over the prey.

The constricting types of snakes kill their prey by winding coils of their bodies around the victim and crushing the life out of it. A boa constrictor can break the bones of a goat or a pig so that the body is a soft shapeless lump of flesh. Great quantities of slimy saliva are poured over the body, so that it becomes slippery and can be easily swallowed.

Have you ever wondered how a snake glides along so fast and so smoothly? Turn any snake over and you will see that the scales on the bottom form an overlapping row of narrow shingles. To these shingles are fastened the lower ends of each pair of ribs, which are jointed to the backbone by ball sockets and controlled by powerful muscles. When each plate is tipped forward and back in a rhythmic succession by these muscles and ribs, it pushes the smooth body of the snake along just as a long sled might be pushed on the ice by scores of boys each jabbing a pair of spikes into the ice and pushing backward.

Perhaps you have heard that snakes can charm their victims by staring at them. Watch the eyes of any snake carefully and you will soon see that the eyes never blink, since they have no lids. To screen them from the glare of the sun, the snake's eyes have glassy films. This glassy, endless stare is what gives people such queer sensations of creepiness.

When the snake sheds its skin, which it does about three times a summer, it cracks open the skin around its lips. Then it crawls out and as it does so the skin turns inside out like a glove when pulled off by the cuff. Then it peels off the film from the eyes. For a few days before molting the snake is blind, irritable, and naturally very likely to bite.

Another mistaken notion that is widely prevalent is that the black-forked red thing darting out of the snake's mouth is poisonous. Boys sometimes cut that off, thinking they are thereby making the snake harmless. This is nothing but the snake's tongue, which is an extremely sensitive organ of touch and taste to teach him the real nature

of the things he comes in contact with. The boys are really only torturing the poor creature and in no way making the snake less venomous.

Like all reptiles, snakes are cold-blooded and their activity is entirely subject to the warmth of their surroundings. Except in the tropics the snakes crawl into their burrows to keep warm on cold nights. They go into a winter sleep in which they become stiff and helpless and all their vital activities are suspended.

Most snakes lay white-shelled elongated eggs much like the eggs of alligators. Snake mothers generally leave their eggs to be hatched by the sun, but in some cases the mother coils herself around the eggs to guard them. In some species, including all rattlesnakes, the eggs hatch inside the mother's body. The baby rattler, when only an hour old, will instinctively take the coiled attitude and strike at his annoyer.

The idea is current that some snake mothers swallow their babies and carry them in their throats until danger is past. Mr. Hornaday in his *American Natural History* says that science has not accepted this idea as proved.

We should remember that snakes as a rule are valuable citizens helping to exterminate rats, mice, and insects and that only in exceptional cases are they more detrimental than helpful to the interests of mankind.

Questions

1. What is the correct way to tell the age of rattlesnakes from the rattles?
2. Why do snakes sound their rattles?

3. What are the fangs and how do they work?
4. How may we be saved from death if bitten by a poisonous snake?
5. How does a snake swallow an animal bigger than itself?
6. How do the nonpoisonous snakes kill their victims?
7. How do snakes move so rapidly without legs?
8. What makes a snake stare continuously without blinking?
9. How does a snake change his skin?
10. Where do some snakes hatch their eggs?
11. How are snakes good citizens?

CHAPTER XXII

A VISIT TO AN ALLIGATOR FARM

I ONCE had a pet alligator in my laboratory in one of the Chicago high schools. During the Christmas vacation the weather became intensely cold, and as the building was not heated that week the various aquaria froze solid. Upon my return to school the following week I discovered my alligator frozen stiff in the center of a cake of ice. Not being very familiar with this reptile, I took it for granted that he was dead, but the school engineer suggested that we thaw him out. So he put the alligator and his coffin of ice in the flue that carried hot air up to the classrooms.

We were busy with our work and forgot all about the poor animal. Along in the forenoon the classes were startled by an unearthly noise apparently issuing right out of the walls of the room. Finally the engineer was sent for, and as soon as he heard the racket he remembered the frozen alligator. Hurrying down into the basement and opening the air flue, he found Mr. Alligator prancing up and down the metal tunnel, which was just a little too warm for the toes of even such a heat-loving reptile. When he saw the open door, he came out on the run and nearly landed in the engineer's arms.

When I was asked to write a story about alligators I wished that I might visit their haunts along the lakes in Florida. I realized that that was out of the question, but

I remembered that there is an alligator farm in Los Angeles, only a half-hour's drive from my home. I have spent a few interesting hours on this unique farm where thousands of alligators live comfortably and naturally in muddy pools under the shade of palm trees and tropical shrubbery. This alligator farm is run by a gentleman who started it twenty years ago and has raised most

BABY ALLIGATORS

After these babies hatched in the incubators they were put in this pen with their own private swimming pool. They love to bask in the hot sun and then swim lazily about in the pool.

of the thousand alligators now living there. He has raised thousands of others besides, which have been sold as pets and as members of menageries, or killed to furnish leather for all sorts of manufactured articles sold at the farm office and elsewhere.

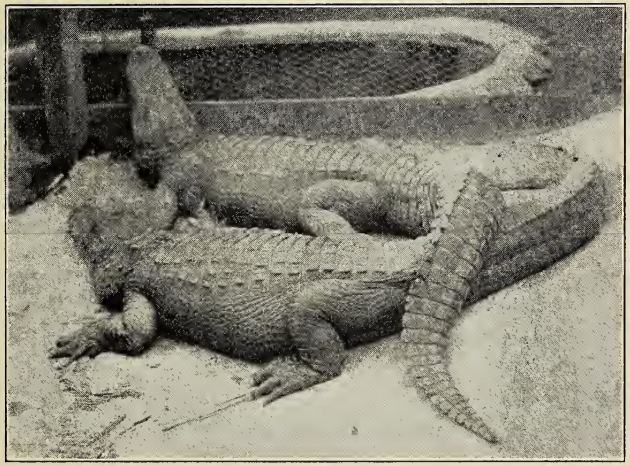
The alligator farm is not large. There are little fenced-in pools scattered all about the grounds under the shade of

trees. The grounds have been made to resemble as closely as possible the natural conditions to which the alligators were accustomed in Florida. In each enclosed pool the animals are of the same size and age; otherwise the older and stronger ones would soon kill and devour the weaker ones.

The older alligators are named, usually after the places where they were captured, such as St. John, Pontchartrain, and Okeechobee. El Diablo was christened "The Devil" because of his devilish disposition. He is a murderer, having killed two of his companions. He is becoming so treacherous that his owner considers it too risky to enter his pen alone. Recently this vicious reptile made an unexpected lunge at the keeper's leg and only missed it by a hair's breadth. When the man touched El Diablo on the snout with his cane, the alligator snapped his huge jaws so quickly that my eyes could not follow the movement. They made a noise in closing like a loud "chop."

Pontchartrain is a huge alligator who has proved himself to be kind and tractable. Visitors have their pictures taken while sitting astride his broad back. With a little coaxing he will rise up on his haunches and open wide his enormous mouth while his picture is snapped by his visitors. Children are allowed the strange sensation of riding on his back, guiding him by a bridle made of a loop of leather around his snout which prevents him from opening his jaws. He is also driven hitched to a low pony cart. Pontchartrain is the best trained alligator on the farm and has earned considerable money by appearing in such motion pictures as "The Lost World." Then his wages were sixty dollars a day.

I shall not attempt to describe an alligator, for you have all seen at least a picture of one. There are a few things I noticed that may be worth mentioning. In size they varied from babies a few inches long to old Okeechobee who is about ten feet long. He is said to be five hundred



OLD ALLIGATORS

These beasts are over six feet in length. Notice the broad snout and the two nostrils near the tip. The body is covered with a tough, leathery hide. The tail by which the alligator swims is so powerful that it can knock a man down or break his leg.

years old. We are told by the natural histories that the largest alligator ever known was thirteen feet long.

The alligator's skin is very tough and leathery, brown in color, with yellow bands in the young but black in the old ones. On the back there are bony ridgelike plates

buried under the skin. The hide may be tanned into very strong and durable leather of a russet color. It is manufactured into suit cases, hand bags, pocket books, book covers, violin cases, and many other things.

The legs are short, crooked, and awkward in use. The alligator lifts his body up on his legs and stumbles along in a very wobbly, uncertain way, walking or falling over his companions if they happen to be in his way. The keeper said the alligator wiggles on his belly like a snake when he is in a hurry, and in that way can travel faster than a man. He creeps about on his legs in shallow water, but in deep water he swims like a fish by bending his powerful tail back and forth. The front feet have five toes, but only the three inner ones have toe nails. He uses the two outer ones for feeling in the mud for worms or clams. The hind feet have only four toes, with nails on the three inner ones. There are only very small webs between the toes; this shows that the alligator does not depend much upon his feet for swimming.

His eyes are small and greenish gray in color, with a vertical slitlike pupil. They are set in each side of the head just above the angle of his enormous mouth. The alligator can see very little straight ahead. If you throw a piece of meat on the ground near him, he has to turn his head over on its side in order to see and pick up the food. He has pointed peglike teeth of different sizes set in the rim of his huge mouth. When he shuts his mouth, the teeth of the upper jaw slide down outside the lower jaw, and the largest of the lower teeth fit up into round sockets in the upper jaw. Such teeth are not able to bite off or chew food, but they are admirably fitted to hold tight to any

fleshy animal that gets clamped between those terrible jaws.

The keeper told me that the closing power of the alligator's jaws is so great that a strong man could not pull the jaws open. When you see the ugly beast lying apparently asleep, as motionless as a dead log, you cannot imagine that he could make a quick movement. The keeper tapped a sleeping alligator gently on the snout with his cane, and we all jumped nearly out of our boots at the surprising speed with which the beast snapped at the stick. We heard a horrible snap and "chop" of the jaws, but our eyes were not able to see the movement of that fierce mouth. Alligators that are apparently asleep often snap a bird on the wing as it flies unsuspectingly near them.

The teeth are not set firmly in deep sockets in the jaw bones like ours, but are all shed every year. The old teeth fall out and are replaced during the winter, at which time the alligators do not eat any food. I found one of these shed teeth on the ground in one of the pens. Its root was absorbed just like those of your baby teeth when they fall out.

The keeper gave us a demonstration of feeding them. He had a big chunk of tough horse meat speared on a pitchfork. He thrust the tines into a crack in the cement floor and held it firmly so that the alligators would not be able to swallow the whole piece, but could only tug at the meat. There were in that pond hundreds of young alligators two or three feet long, and about eight years old. They came scrambling out of the pond and into a "monkey pile" around the fork. When one got his jaws clamped into the hunk of meat, he shut them just like a bear trap, folded

his arms and legs close against his sides, and then, by means of his powerful tail, he rolled over and over sideways until his jaws twisted off a piece of meat. It was a novel sight to see dozens of these strange beasts rolling like blocks of wood in a turning lathe.

In the same way alligators destroy their prey or foes. They grab a leg and then start that irresistible twisting which literally tears the limb from the body. The keeper said he was afraid to throw a piece of meat into the mass of alligators for fear that a piece might fall upon the leg of an animal and another alligator might grab this leg and twist it off.

There were dozens of crippled alligators which had lost one or two legs and maybe half of the tail in the fights between these blood-hungry monsters. They had to have a hospital at the farm for treating the worst cases of injury.

We did not have a chance to see the way alligators drown their victims without suffocating themselves. In the wilds they seize an animal by his nose as he leans down to drink and jerk him into the water. As they let themselves sink they drag him under. They shut their nostrils in the front of their long snouts by closing down flaplike valves, and then close the rear of their mouths by raising a flap at the back of the tongue so that it meets the palate or roof of the mouth and prevents any water in the mouth from going down the gullet or windpipe. Being cold-blooded, they are not so dependent upon a supply of air, and with these two means of preventing themselves from swallowing water, they are able to hold the victims until they drown.

Besides this they are able to raise the head so that only

the nostrils on the tip of the snout rise to the surface. Then, by opening the valves, the air can go down over the palate and behind the tongue into the windpipe without danger of water choking them. Sometimes a wild pig ventures to drink near an apparent log floating near shore, only to receive a terrific blow from the tail of the loglike

Alligators Hatching

The alligator builds a nest on the shore composed of dead leaves and grasses. Her eggs are oval and the baby breaks its way out of one end. As soon as the babies are able to go into the water they take care of themselves.

alligator. As the tail knocks the pig around to one side, the alligator's mouth snaps suddenly around to the same side so that the gaping jaws catch the poor pig on the fly. The alligators can lie like logs in the river with only the nostrils and eyes at the surface, thus being invisible to their prey, yet able to breathe and keep a sharp lookout.

The older alligators made a queer hissing, grunting noise whenever the keeper disturbed them by thumping on the fence with his cane. It sounded somewhat like that made by a snake, and somewhat like that made by a hog. In the mating season the males bellow like bulls. They also seem to bellow when there is a change of weather; the keeper asserted that he could predict storms by the behavior of his alligators.

The alligators become mature at about twenty years of age. In September the female builds a nest on the shore out of leaves, grass, and rotting vegetation. She then lays from twenty to eighty white-shelled eggs that look like goose eggs except that they are oval and the same size at each end. The yolk of the alligator's egg is white, the same as the surrounding albumen. The eggs are buried in the pile of vegetation and hatch in sixty days by the heat of the decomposing mass. In order to avoid the risk of losing the eggs by accidents, the keeper hatches them in a regular poultry incubator run at 80 degrees, and broods the baby alligators in a heated brooder for only a few days.

The baby breaks out through the end of the shell just as a chick does. In the native state, the mother alligator hears the cries of her babies as they hatch, digs them out of the pile, and gives them a ride into the pond on her back. As soon as they are able to swim and get away from her, they hide in the weeds in the shallows, for the mother would be likely to gobble up her own children.

Alligators are cold-blooded, which means that their blood temperature varies according to their surroundings and their activity rises and falls as the temperature. In

hot weather they are active and hungry, while in cold weather they get more and more sluggish, finally going into a dormant winter sleep and becoming stiff and helpless, with no appetite. In their native haunts they burrow into the mud at the bottom of the ponds or underneath the banks. They sometimes dig a tunnel and sleep all winter huddled together in a pile. Hunters take advantage of this habit to capture the huge old animals that are helpless and harmless at that time. Some men even dare to crawl into these winter lairs to drag the monsters out by their tails.

In closing I want to tell you how the alligators shoot the chutes. In one pen a regular slide just like those for children in playgrounds or plunges is built beside the alligators' pond. It is at least twelve feet high. The keeper grabs a four-foot alligator and drags him by the tail to the stairway at the back of the slide. He pushes the animal's head into the end of the incline and makes a loud noise on the boards with his stick. The alligator climbs up the cleated incline without more ado, and when he reaches the top, he waits on the platform till the keeper and the visitors have walked around to the foot of the slide on the opposite side. Then, at the command of the keeper, the alligator pushes his head over the edge and down he slides headfirst into the pond with a splash that carries him across to the opposite side. He seems to enjoy the plunge, but he does not have sense enough to perform the trick of his own accord. Who would have thought that such a stupid-looking reptile could learn even such a simple trick?

I am sure you would enjoy a visit to the alligator farm just as have the thousands whose names are scribbled in the visitor's book which is kept in the office.

Questions

1. What happened to the alligator in the school?
2. Why must alligators that are to be kept together be all of the same size?
3. How can one judge the age of alligators?
4. In what two ways do alligators move over the ground?
5. How do they move rapidly in the water?
6. What is peculiar about an alligator's teeth?
7. For what are his teeth fitted?
8. How do alligators tear the meat from their victims?
9. How do they catch wild pigs?
10. How do they hatch their eggs and rear their babies?
11. What does it mean to be cold-blooded?

CHAPTER XXIII

FEATHERED FRIENDS

NATURE experimented with flying animals long before she brought out her feathered model, the bird. Insects were the first aviators, and they have been so successful that they are considered today to be man's greatest rival in the struggle to rule the world. Nature has also experimented with flying fishes, flying frogs, flying lizards, flying squirrels, and flying bats.

The oldest known bird fossil shows alligatorlike teeth in the beak and three clawed fingers in the feathered wings. It also shows a long lizardlike tail with two rows of flat feathers by which the bird must have steered its course. Our modern birds have discarded the teeth and specialized the beak into a great variety of forms fitted for all sorts of food. They have lost the fingers on the wings, but have perfected the wing feathers to give endurance, speed, and control. The tail has been shortened into a compact fan. This permits of very rapid steering and also acts as a powerful brake.

The bird's feathers are arranged over the body and wings in the same manner as scales are on reptiles. They seem to be highly developed scales perfected for holding heat in the bird's body. They also ward off the wind and serve as levers to lift the bird up into the air.

The quill of the feather is a very strong hollow tube of horn. The vane, or soft part of the feather, resists the

air. The barbs are thousands of lateral fibers held together by stiff hairs and fastened together by hooks and eyes. The stiff feathers used in flying overlap like shutters so that they hold the air on the down strokes. but per-

GULLS

These gulls are *tireless fishers* and find their food on the surface of ocean or lake. Their long wings enable them to fly easily all day long. They can sail without effort when they find upward currents in the air.

mit it to slip through without resistance on the back strokes.

Like the airplane, the bird's body is made as light as possible with the greatest strength. The bones are made of dense ivorylike material constructed in the form of hollow cylinders like the tubes of a bicycle frame. In many cases they are filled with air sacs which are connected with the lungs.

The bird's breast muscles are very large. The breast bone is developed like the keel of a sailboat to give sufficient support for these strong muscles. The heart is very powerful and beats at a higher speed than the hearts of other animals of the same size. The bird's blood temperature is fever heat compared with that of land animals.

There are many sizes and forms of birds, varying from humming birds to the giant ostrich, from flapping penguins to long-winged stormy petrels, from clumsy ducks to agile swallows.

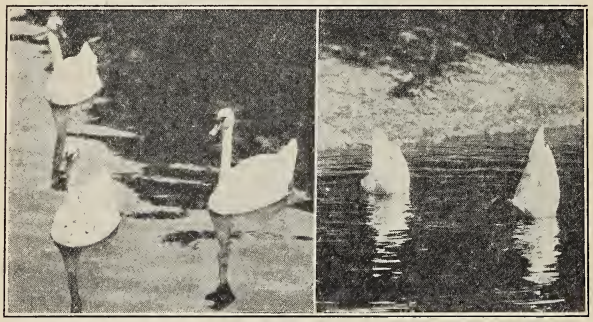
In order to get a bird's-eye view of the bird's place in nature, let us use the names and grouping so ably presented in Wright's *Citizen Bird.*

We see patrolling the vast expanse of ocean, lake, and marsh the long-winged, web-footed water birds. These are the gulls, terns, and stormy petrels. They are the *tireless fishers* that pounce down upon the live or dead fishes on the surface waters. They help to hold in check the overpopulation of the earth's waters. They also purify them of the carrion that would soon endanger the lives of creatures by polluting the water. In order to handle this form of food, these birds have either daggerlike bills or sharp hooked beaks.

The *surface skimmers* are the web-footed swimming birds that spend much of their time riding gracefully on the bosom of the lake or ocean. They feed by straining out the small living creatures so abundant on surface waters. Most of the ducks, geese, and swans have flat bills with comblike fringes along the sides to enable them to strain out their food by squirting the water through the sides of their mouths. These birds have an amusing habit

of standing on their heads in the water in order to reach as far down as possible for food. The oil glands are greatly developed in birds which spend so much time in the water. Their feathers are so well oiled that their bodies are kept dry. We have an old saying: "It runs off like water off a duck's back."

Another group of birds make their living by diving to



SWANS

These white swans are *surface skimmers*. Those on the right have tilted their bodies on end so that their long necks may reach full length to the bottom. These birds skim the small food particles out of mud and water.

the bottom of pond or lake to catch fish or other forms of life. They are therefore called *bottom searchers* and include such birds as loons, grebes, and coots. The bottom searchers have short powerful wings and webbed toes on their feet. The legs are fastened very far back under long bodies. These birds really fly under water and can easily dive and swim under water the length of an ordinary pond or lake.

If you visit any marshes or weedy lakes, you will find two peculiar kinds of shore birds that patrol the edges of ponds either in the water or along the beaches. The storks, cranes, herons, egrets, bitterns, and rails are long-legged waders. They have very long necks and long daggerlike bills. These birds stand as motionless as a post and, protected by their camouflage coloring, are not noticed by fish or frog. With lightninglike speed their dagger beaks spear the unwary creatures; for this reason they have been nicknamed *frog stabbers*. Most of these queer birds make unearthly noises like grunts, groans, or choking cries.

HERONS

These are *frog stabbers* that stalk about in the shallow marshes after fish and frogs. Their long legs and long toes enable them to wade in the water without wetting their feathers and to walk on soft mud without sinking.

The smaller shore birds like the woodcock, jacksnipe, plovers, and sandpipers are called *mud probers*. They run along the mud flats on the beach when the tide is out,

or along the muddy shores of lake or river, and probe their slender beaks here and there into the mud in search of worm or insect. They are keen of hearing, and the tips of their bills are very sensitive; thus they are very skillful in locating and extracting the creatures buried in the mud.

Turkeys, prairie hens, quail, grouse, and pheasants represent a group of *ground gleaners* who search back and forth over the fields and plains for all sorts of dry-land insects and seeds. In the days when grain crops were har-

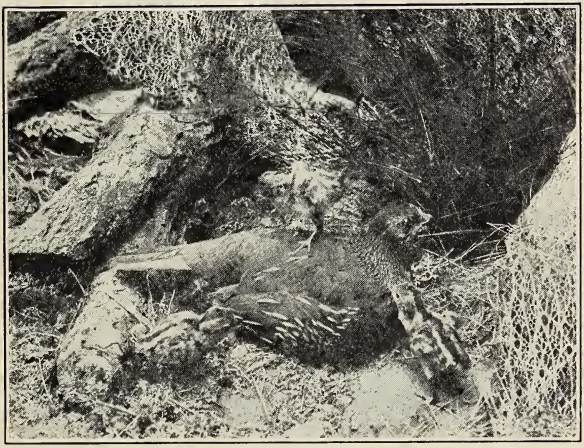
THE KILLDEER PLOVER

These dainty little birds are *mud probers*. They run along the mud flats beside lake or river and search for worms or insects in the mud. Their wings are long so that the birds can fly long distances.

vested by hand, the reapers were followed by poor people who gleaned the stray heads of grain overlooked by the harvesters. Like these gleaners, birds may be seen today roaming over our grain fields after a harvest, chasing grasshoppers, and picking up stray kernels of wheat or corn. The ground gleaners have powerful legs and stout toes armed with good scratching toe nails. The beaks are short, stout, and curved so that they can be used for picking grains of food out of the dirt. Their plumage is usu-

ally colored to match the grass, weeds, and ground of the fields where they work.

There are a large number of small birds such as sparrows, finches, and linnets that may be called *weed warriors.* They are well fitted to wage war against the weed pests by



QUAIL AND CHICKS

The quail belongs to the *ground gleaners* and roams over the fields. The color markings of the babies make them invisible when they lie motionless on the ground or among the dead leaves.

eating a great part of their many seeds. These little birds work in large flocks. They have short, stout, pointed beaks like pairs of pinchers and short, stout wings which enable them to dart in and out of weed patches and escape their hawk enemies. They are colored much like the weeds and ground and accordingly are not very conspicuous. Many of these birds are wonderful songsters.

Seed sowers are those somewhat larger birds, such as the robin, thrush, thrasher, cat bird, and waxwing, that eat the fleshy fruits of trees and bushes. The hard indigestible seeds gradually pass through the alimentary canal and are later dropped upon the earth. These seeds sink into the ground miles from the parent tree, where they sprout and form new plants. It is believed that most of our flowering, berry-forming shrubs have been scattered over the land by the aid of these beautiful songsters.

Many insects place their eggs in the crevices of the bark of trees so that their wormlike grubs may burrow deep into the bark or wood to hide away from their enemies. The woodpeckers are nature's *tree surgeons,* for they listen with their heads against the tree trunks like a doctor sounding a person's heart and lungs. Then they drill skillfully through the hard wood or bark and extract the luckless worm by means of their long barbed, harpoon tongue. The woodpecker's beak is long and strong, and is used like a carpenter's chisel. The toes are twisted so that two point forward and two backward. Thus the foot can cling to the bark of a tree and hold the bird to the tree trunk like grappling irons used by men who climb telegraph poles. The tail feathers are very stiff and end in wirelike points which are jabbed into the tree when the bird clings to the trunk, thus giving him an additional brace. Woodpeckers have taken advantage of their tapping noises to establish a kind of telegraph code of communication among themselves.

One of the woodpeckers has developed a peculiar habit of drilling holes in the live bark so that little pools of sap may collect and attract ants and other insects. These

the birds gobble up while making their rounds. A California woodpecker drills holes in the bark and stuffs acorns into them. Certain insects deposit their eggs inside the acorns so that their grubs may feast on the meats of the

WOODPECKERS

With their stubby tails these birds brace themselves against a tree while they cling to the bark with their hooked toes. Their long, stout beaks can bore through solid wood to the worms and grubs that are hidden beneath.

nuts. The woodpeckers return just in time to harvest the crop of worms inside their acorn traps.

The leaves and flowers of trees are likely to be infested with plant lice and other sap-sucking insects. The beautiful little wood warblers are veritable acrobats as they peep under each leaf and visit each blossom. They pick out the wee bugs by means of their tiny tweezerlike bills.

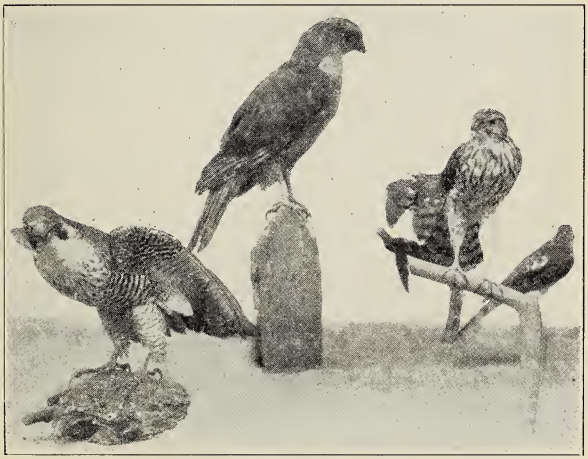
Since the air is full of insects from the size of gnats to butterflies, there is a group of birds which make a business of sweeping the skies free of bugs. They have been named *sky sweepers* and are represented by the swallows, flycatchers, and nighthawks. The flycatchers dart out from their homes in the trees, snap up the flying insects, and return to their nests to feed their young. The swallows are wonderful aviators as they skim along above the water or soar through the azure sky at a speed of from sixty to one hundred miles an hour. Their beaks are small, but their mouths open very wide and are bordered by curved bristles which skim the bugs out of the air as they dash along. When they have satisfied their hunger and filled their mouths full for their babies, they line up on the telegraph wires or dart back to their mud nests under the eaves of the barn or in the walls or cliffs.

Birds multiply so fast that they are likely to become as great pests as insects unless they are kept in check. Besides their enemies the snakes, squirrels, and cats, there is one group of big birds that prey upon the smaller ones. Eagles, hawks, and owls are called the *silent watchers*. They have the habit of sitting quietly on perches on the top of a tree or a cliff to watch the panorama of life on the earth beneath until such time as they feel called upon to interfere in the drama.

The eagles and hawks are on patrol duty during the day while the owls act as night watchmen. The day policemen are provided with eyes like telescopes. They have wide-spreading wings so that they may soar in great circles in the sky and see the unwary creature which has ventured too far from shelter or the weakened creature which

has dropped dead in its track. The vultures that feed on dead bodies have a highly developed sense of smell and usually appear as by magic wherever an animal dies.

Some hawks are very swift flyers. They spread havoc among the small birds and the small furry creatures on



HAWKS

These *silent watchers* are called birds of prey from their ferociousness in attacking other birds and beasts. They have hooked beaks capable of tearing flesh, and sharp claws or talons for seizing and carrying their victims.

the ground. We are apt to think of these birds as blood-thirsty villains which destroy our beautiful songsters. But we must realize that most of them do much more good than harm by keeping down the hordes of furry pests, such as rats, mice, gophers, and moles.

Being so well fitted for traveling through the air, birds have been most successful in developing the habit of migration in order to escape the cold and food shortage of winter. This habit seems to have originated during the great ice ages when the northern hemisphere was buried under sheets of ice called glaciers. Many of our birds migrate today through force of habit. Some migrate only in the severest winters, and certain other birds do not migrate at all. Naturally the fruit- and insect-eating birds are compelled to seek the lands where it is always summer.

Each species of bird has its own time schedule for migrating and its own route. As a rule the last bird to leave in the fall is the first to return in the spring. Some birds travel in flocks under the leadership of a guide and some travel in pairs. But most birds go south in huge flocks and return in mated pairs. Many birds go south by one route and return over a different one, but these routes are the same year after year, as though marked out by the fathers and mothers.

The tiny humming bird journeys from Canada to Brazil. The golden plover breeds within the Arctic Circle. They are the gypsies of the bird world. They get together in early fall in Nova Scotia and fly over the Atlantic Ocean to South America in a nonstop flight. They wander south to the very tip end of South America and then journey north along the Andes and Rocky Mountains to reach their summer home in the Arctic Circle. Here they perform their housekeeping and brood-raising in a short six weeks' period.

Questions

1. What animals besides birds fly?
2. How are the feathers of birds like the scales of reptiles?
3. Why is a bird so light?
4. How is a bird like a fish?
5. Why is it unwise to destroy the birds?
6. What birds are the tireless fishers?
7. How do water birds that feed on the surface differ from those that feed on the bottom under water?
8. Why do storks, cranes, and herons have such long legs?
9. How are birds aided by their color?
10. Why are woodpeckers called tree surgeons?

CHAPTER XXIV

FURRY FRIENDS

WE find buried in the Rocky Mountains the fossil remains of a great group of animals that are not living today. These giant reptiles, which are called dinosaurs, resemble many of the higher animals of today, such as our birds, whales, and elephants. The huge reptiles of ages ago were cold-blooded, like alligators or snakes, and that may help to account for their disappearance after the more modern and highly developed warm-blooded creatures came on the stage.

The fossil remains of the warm-blooded, hair-covered animals that we call mammals (or mama-animals, because they feed their babies with milk from their breasts) tell a wonderful story of development. The horse started as a fox-sized creature with several hoofs on each foot, as the pig has today. The elephant at first had neither trunk nor tusks, and at one time was covered with long hair.

There are a few survivors of these ancient animals. In New Zealand there lives a queer furry creature called a duckbill. Its body resembles a beaver's, but its mouth has a horny bill like a duck's, rather than the toothed jaws we might expect. Its feet are webbed like a duck's and it swims with great skill.

The strangest thing about this furry animal is its habit of laying large, white, shell-covered eggs quite like those

of a duck. The mother animal broods over her eggs like a hen and hatches out wet little hairy ratlike babies. The babies are far too helpless even to suck milk; so the mother picks them up and fastens each baby's mouth to a milk nipple and feeds her brood by squirting milk down their throats at proper intervals of time. These duck-bill animals are called the *egg-laying mammals.*

When Australia was discovered by civilized man, it was found that all the fur-covered animals, the kangaroos and opossums, were unlike those which are most common in the rest of the world. Only our North American opossum and a few animals in South America are like them. The mothers of all these creatures have folds of furry skin on their abdomens developed into warm bags in which the babies are placed immediately after being born. The milk-gland nipples are situated on the skin inside this pouch; thus the babies may be fed without the trouble or risk of taking them out of their bed. The mother can leap away from danger without leaving her helpless babies behind as deer and such animals often do. When an enemy appears, the young kangaroo jumps into the mother's pouch. The kangaroos and opossums are called *pouched animals.*

All the rest of the hairy or furry animals have been provided with a still better means of taking care of their babies. They have a pouch for their babies, but it is entirely inside the mother's body, and the baby grows in there from a tiny egg until it is so completely developed that it can be safely cared for without this protection. As the baby is from the beginning attached to the inner lining of this pouch, it can get food and oxygen from the

mother's blood, which is strained through thin membranes into the baby's own blood vessels. This is the most wonderful and perfect method of raising babies that is to be found in the world.

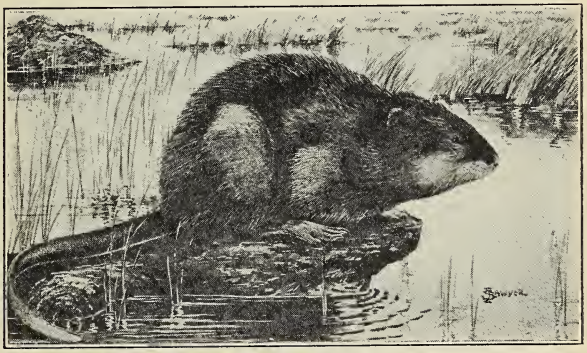
The length of time that babies can reside inside this well-protected and food-supplying home varies from a few weeks in mice to two whole years in the elephant. As soon as these babies sever their connections with their mothers, their food supply of blood is cut off and milk is supplied instead as rapidly as the little stomachs can digest it.

Such mammals are equally distinguished for the size and complexity of their brains. We find that they possess remarkable brains, the highest members even rivaling man in all but reasoning powers. The lowest members of the mammals, such as the anteaters and armadillos, seem to be so unintelligent that they are called "the animals that can't be educated." Poorly developed brains are also found among the group of rodents, or gnawing animals, such as rats, rabbits, and beavers. Although the beaver exhibits wonderful skill in felling trees and building dams, it is believed that his actions are governed by instinct just as the bird builds a perfect nest without having had any experience. However, in the dog, horse, elephant, and monkey we find such remarkable acts that the question is raised whether animals think, remember, and reason.

When we study this great group of animals, the mammals, we find them adapted to their surroundings in much the same way that we found the various groups of birds.

The whales, porpoises, sea cows, seals, and walruses are so perfectly adapted to a life in the water that many persons consider them fishes. On the contrary, they are

mammals like the horse and cow. Their feet are so changed into flippers that they no longer resemble feet and are almost useless for locomotion on land. Although these animals seem to be perfectly at ease in the water, they are obliged to come to the surface occasionally to empty the bad air out of their lungs and fill them with pure fresh air.



A Muskrat

Beavers and muskrats build their houses in the sand and find their food in roots or the bark of plants growing in water. The hippopotamus and tapir find ideal conditions in the shallow waters of river and bayou. The mole leads a strictly underground life as a burrower under the soil, while the prairie dogs, gophers, and many other burrowing animals feed above ground but escape from their enemies by hiding in their underground homes.

The sloth is so peculiarly adapted to living in trees that he is as awkward on land as a seal. He suspends his body

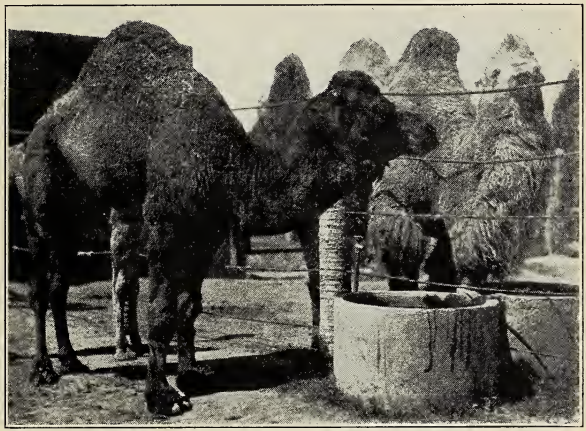
under a limb by means of his curved toes and gets his food and drink out of the juicy leaves. The squirrel and monkey are very much at home in trees, thus escaping the attacks of those enemies that cannot climb.

The herbivorous, or grass-eating, mammals, as a rule are long-legged, swift-running creatures. They cover miles of prairie or forest in order to obtain enough of their coarse vegetable food and to escape their bloodthirsty enemies. In order to eat quickly when they find good grazing and to be able to chew their food while hidden in some secluded spot, they have several stomachs. Deer, buffaloes, sheep, and cows have four stomachs.

The first stomach, or paunch, is merely a storehouse; the second is a small muscular pouch which forms cuds or balls of food much as a boy rolls snowballs. When the proper time arrives, this stomach sends the cuds rolling back up into the mouth to be chewed thoroughly at the animal's leisure. The other stomachs are concerned in the straining and digestion of the food.

This is the group of animals that furnishes man with his beasts of burden and with much of his food and clothing. The cow gives milk and butter, and veal and beef in all their forms. Less than a hundred years ago oxen did most of our farm work. From the cow's hide we make shoes, harness, and many kinds of leather goods. The sheep supplies us with lamb and mutton and our woolen goods. The pig is the source of bacon, ham, pork, and lard. In western lands the horse has been our most valuable beast of burden, and his hide has made very fine leather shoes. In eastern lands the camel, elephant, donkey, water buffalo, and reindeer are invaluable helpers to man. The

camel is especially valuable as a beast of burden in desert countries because he is well adapted to desert conditions. He can go without water for long periods of time for he can store a reserve supply in honeycomb pouches in the walls of his stomach. His woolly hair is a protection from the



CAMELS

This picture shows two forms of camels used as beasts of burden. The single-humped camel is called dromedary, and the double-humped one is the Bactrian camel. Food, in the form of fat, is stored in the humps during the season when green grass is abundant.

blazing sun of the desert day and from the penetrating cold of the desert night.

Another great group of mammals is the carnivorous, or flesh-eating, type. This includes the dog and cat families, the bears, seals, and the martens, as well as most of the animals that give us our most beautiful and valuable

furs. These animals have unusual teeth — long, dagger-like teeth called canines, and triangular sharp molars that shear through meat like a pair of scissors. They live on flesh alone and in most cases are fierce, bloodthirsty beasts. They serve as checks upon the vegetable-eating beasts much as the birds of prey check the insect-eating and seed-eating birds.

It is interesting to see how the senses and the instincts of these creatures have been perfected. Deer and most of the grass-eating quadrupeds have a very keen sense of smell and are able to detect the presence of an enemy a mile away if the wind is blowing toward them. In order to have any chance to catch a deer, it was necessary that its enemy, the wolf, should overcome this handicap. The sense of smell is so highly developed in the wolf that he can detect the smell of the deer's footprints even a day after the animal makes them. The deer has large eyes and big ears that can be turned about to catch sight and sound from any direction; so the wolf has developed cunning and stealthiness that enable him to outwit his wary prey. The deer has long legs and can run very rapidly for short distances; the wolf has stout legs and great endurance, so that he is able to tire out the deer.

The deer tries to lead the wolves away from her hidden baby fawn, and has developed the habit of running in a great circle so that she will return near her home and her baby by the time she has eluded her pursuers. The wolves have learned to cut across the circle to save time, and the pack take turns in a relay race so that they may combine to tire out the fleet deer. The deer is colored like the dried

grass and dead leaves in order to be invisible to her pursuers, but the wolves are colored like the ground in order that the deer may not see them approaching.

The grass-eaters have perfected the use of body colors to a remarkable degree. These color markings are very

THE WHITETAIL DEER

This deer gets its name from the conspicuous way in which it flashes the white underside of its tail when running.

conspicuous in the deer and antelope families. The forehead and breast are marked with patterns of black, white, or tan. Many of these animals also wear a distinctive color pattern on the rump or hind legs. Whenever the animal is startled by an enemy or any strange being, it turns and dashes away displaying this symbol of retreat, which serves as a beckoning signal to the young fawns or other members of the herd. The reaction to fright causes

the muscles under the skin of these color patches to spread the hairs wide apart so that the patch will show more conspicuously, just as fright makes the hair stand on end. We find this same behavior of hair in the fierce carnivorous animals, when the wolves or dogs bristle up their manes or the cats stick up their backs or puff up their tails.

Some of the deer family have scent bags or perfume bottles.

In the rodent or gnawing group we find a similar story. The gophers and chipmunks have short legs and slender bodies that enable them to elude most of their enemies by creeping into their underground tunnels. Their bloodthirsty enemies, like the ermine or weasel, also have long slender bodies and short legs, and are able to follow their prey into their burrows.

The rabbit is brown in summer and white in winter. Thus he can hide from his enemy, the ermine. But the ermine also changes color from brown to white in order to fool the rabbit.

The squirrel's sharp curved claws enable him to climb trees to escape his enemies, but the cat family has also grown long curved claws so that they too can climb trees. The timid rabbits hide in the daytime and come out at night to feed; therefore the cats have slitlike pupils in their eyes so that they too can see at night.

Thus these creatures play the game of hide and seek, with death as the penalty for the loser. The pursued animal must develop his color, his keen sense, length of legs, and types of teeth, and depend on the instinctive habits that enable him to find his food and escape his enemies. The pursuer must counteract each of these adaptations

either with a similar development or with an entirely different one that may give him an advantage over his fleeing prey.

In the long run each type of animal seems just about to hold its own; so each must be given about an even chance in this struggle for existence. While the actual death struggle is a pitiful sight, it is evident that this struggle has compelled each animal to do his best and to keep improving his body and his habits. Thus is developed a more and more perfect animal.

By his discovery of the laws of reproduction and heredity, man has been able so to control reproduction and guide heredity that he has completely changed the form and nature of various animals, practically creating new forms, as in the case of the mule.

A visit to the stock show at one of our state fairs will show you scores of forms of our domestic animals that never existed in the wild state. All these artificially created forms of animal life would tend to go back to the behavior of their wild ancestors if released from man's restraining hand. We see this in the case of escaped horses and cattle on the great plains, and the reversion of dogs that have joined a pack of wolves.

An experiment was once made by turning loose in a huge dovecote one pair of each of our fancy pigeons, such as fantails, pouters, tumblers, nuns, barbs, and carriers. These pigeons mated in all sorts of combinations and in a few generations all of them looked alike and all resembled the wild blue rock pigeon, which is believed to be the ancestor of all modern pigeons. We see these tame blue pigeons in any flock of pigeons that inhabit the lofts

of churches or public buildings and seek their food from the streets.

Questions

1. Why do you suppose dinosaurs disappeared from the earth?
2. What animals are called mammals?
3. What is peculiar about the duckbill?
4. What are the pouched mammals?
5. Can the beaver reason and think?
6. Can the horse or the monkey think?
7. Are whales fishes?
8. Why do grass-eating animals have so many stomachs?
9. What kinds of teeth have the flesh-eaters?
10. Why do not some animals kill off all their enemies?
11. How has man changed some animals?

CHAPTER XXV

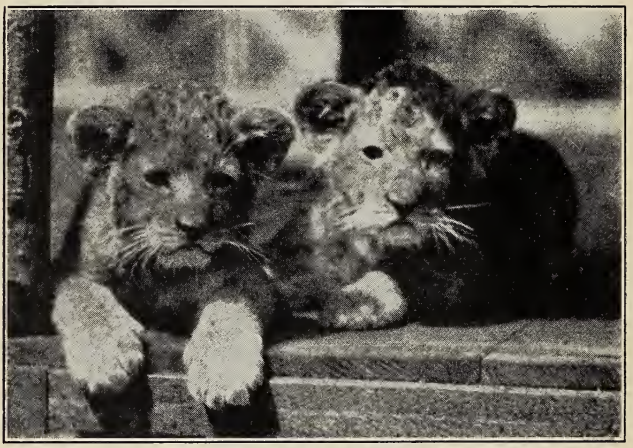
A VISIT TO THE LION FARM

NOT long ago I had the pleasure of spending a day on a lion farm near a big western city where hundreds of lions live a natural outdoor life, and where hundreds of baby lions are successfully raised each year. Think of raising lions on goat's milk fed out of a baby's nursing bottle!

The wife of the lion trainer brought Diana, the baby lioness, from her crib, held her in her arms as though she were a human baby, and let her drink out of a regular nursing bottle. Diana was so hungry that she guzzled her dinner too fast and had a stomachache. The trainer's wife rubbed the little "tummy" and cuddled the lion cub in her arms until the baby got rid of the gas which troubled her. Diana, by the way, was only one week old, but she had already earned ten dollars by having her picture taken for a motion picture.

The adopted babies are fed every two hours from daylight till bedtime. The lion-trainer's wife said she used to get up at night to feed them at regular intervals, until she found herself mothering nine baby lions at one time; then she decided that she preferred to sleep. You may be surprised to learn that the young lion mothers quite commonly do not seem pleased to have babies, for they neglect

them pitiably or actually eat them up, but after they have had a few litters of cubs, they show the greatest devotion to their babies. Diana's mother was disappointed at finding only one cub when she expected four; so she acted very peevishly and treated her baby so roughly that the trainer thought it wise to kidnap her and let his wife play foster mother to the cub. It was hard to believe that dozens of



BABY LIONS

These baby lions look very much like baby kittens except that they are much larger.

the magnificent, full-grown lions on this farm had been raised as lambs and pigs are sometimes raised by a farmer's wife or daughter.

We went into the lion house where the faithful mother lions were nursing their families of cubs. Each family oc-

cupied a large clean cage with strong bar gratings in front. There was a new litter of three cubs born the night before. They lay sleeping on clean straw. Their eyes were closed, as is the custom of newly born cat babies. Some baby lions are born with their eyes open, but they do not seem to see any sooner than those who open their eyes a week later. The eyes of all baby lions are blue at first, and gradually turn yellow. While I was there, one mother became enraged because the keeper tried to adjust the footboard in front of the cage. She dashed headlong against the bars, gnashed her great yellow teeth, reached out through the bars, with her daggerlike claws wide open, and gave blood-curdling growls. Her eyes fairly burned with a baleful green gleam.

The lion cubs are spotted all over with the same peculiar groups of color spots that distinguish a jaguar or a leopard. In the native haunts of lions these spots on the tawny hide match the shadows on the yellow sand and hide the baby from its enemies. The spots disappear gradually and are all gone by the time the lion is big and strong enough to fight his way in his world of tooth and claw.

As soon as the cubs are weaned, all those of the same size and age are placed in a big iron-fenced yard with some shade trees. These clumsy, awkward babies were quite shy, skulking away into the far corners, hissing and spitting when cornered, and bleating like kids when captured by the trainer. At one side of the yard is their house, where they can retire at night, for it is too cold even in summer time for them to sleep outdoors. Even the fully grown lions are shut up in their indoor cages from five at night to seven in the morning.

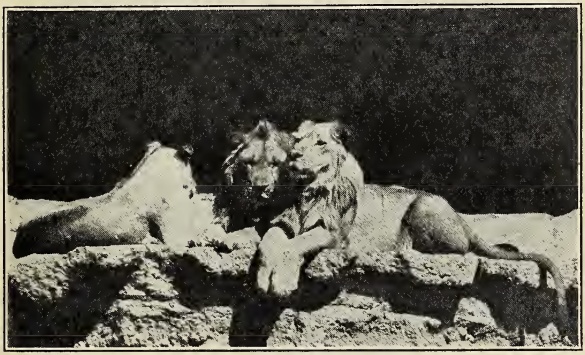
Whenever there happens to be a cub smaller or younger than the others, he is kept in a cage like a chicken coop on the lawn just behind the office. When I visited the farm, there were three cubs in the pen only a few weeks old. One was named Menelik. The other two had been christened Miss Alhambra and Miss El Monte because the Lions Clubs of those two neighboring cities had happened to visit the farm the day they were born. Every afternoon after the public has been excluded and the gates are shut, these little cubs are allowed freedom on the beautiful shaded lawn inside the enclosure. They romp about, pull each other's tails, chase each other, and frolic with the fox terrier. The last pair before these to enjoy this freedom were Cæsar and Brutus. They grew to be as big as police dogs while still enjoying their romps all over the farm.

But one day Cæsar happened to meet a stately peacock just as he was strutting about showing off his beautiful fan tail. That was too great a temptation for Cæsar, who made one grab and came away with all of the peacock's beauty. Since then he has been confined in a closed yard. He is a great favorite with the trainer and comes bounding up to the door whenever his name is called. Cæsar throws himself on his back, rolls over and over like a puppy, and sticks out his paws to be patted by his keeper.

I was astounded when the trainer opened the gate of one of the big outdoor pens and walked into the midst of dozens of full-grown lions with the same unconcern that a farmer would have shown in entering a pasture where his cattle were grazing. Big lions were lying about on the ground, some of them blocking the gateway. The trainer called each one by name and ordered them out of the way. They obeyed like well-trained dogs. As he

walked about among these lions, he gave them a slap with his hand or a sharp blow with the rattan cane he always carries. They showed no resentment, neither snarling nor showing their teeth, and just lumbered out of his way and slumped down on the ground and dozed off again.

Anyone who asserts that these beasts were drugged to



A Lion Family

The old male in the center of the group shows the characteristic mane that makes him look so much more ferocious than the female. The paws hanging over the edge of the rock show how strong and big the feet of lions are. Hidden within those furry paws are knifelike claws with which the lion is able to tear his prey to pieces. Notice the look of calm assurance of these great beasts that are afraid of nothing.

keep them quiet should see these same lions while they are being fed. They are fed once a day between two and four o'clock. Each group of lions is fed in the following way: A portable covered runway is rolled across the pathway between the pasture and the lion house. When the gates at each end are raised, the lions rush into the house like a bunch of steers.

One of the attendants went into the pasture and drove out the stragglers just as a farmer's boy drives home the cows. The lions trooped back and forth through the long row of cages, for all the sliding doors between the separate compartments were open. The attendant walked along in front of the cages, calling each lion by name, and, with the help of a long rod, he soon had each lion in his own compartment and the doors closed between them. It all reminded me of the way I used to drive the cows into the barn and get each cow into her own stanchion.

The lions knew what was coming, and their whole behavior instantly changed. Snarling and growling, they paced rapidly back and forth in front of the bars, pawed at the closed doors, and stood up on their hind legs, reaching out between the bars and trying to strike the attendant. I do not believe any man would have dared to enter one of those cages at such a time. Before feeding the lions the cages are sprayed with some fly-killing oil, for the flesh flies seem to anticipate the approaching dinner of raw meat, which arrives on a wheelbarrow.

Each lion got a fourteen-pound piece of fresh raw horse meat. The lions did not show very good manners, for they reached out their paws and snatched their share before the man could poke it between the bars. With mighty growls they squatted down with the flesh held between their powerful paws and tore off chunks with their saberlike canine teeth. I was surprised that they did not unsheathe their sharp claws, but they seemed to reserve these terrible weapons for their enemies or for live struggling victims. It did not take the lions half an hour to finish their meal. The attendants raked out the bones,

for the lion does not crunch bones like a dog or wolf. The outdoor chute was then opened, and the lions marched out into the pasture as meek as kittens, ready to be

PRINCESS, A TRAINED LIONESS

handled again like sheep. What a transformation in a few minutes!

While the lions were feeding indoors the attendants had placed large pans of fresh water in the pasture lots. As soon as the lions emerged from their houses they loped to

these pans, crouched down, and lapped up the water just like a lot of tabby cats lapping milk on the kitchen floor. It was hard to realize that the king of beasts could be handled, herded, and pastured in the same way that cattle are. The trainer said he had handled as many as thirty-five lions together at one time in an open pasture. with nothing but a rattan cane.

These lions earn a great deal of money for their owner by acting in motion pictures. Most of the pictures are "shot" right in these lion pastures with suitable scenic backgrounds to resemble African jungles or deserts. Occasionally it is more convenient to lead the lions into cages on trucks and carry them to Hollywood.

The trainer walked into one pasture where there were ten full-grown beasts each weighing about five hundred pounds. The older lions are the most magnificent in appearance and the most wonderfully trained. Each responded promptly to the call of his name and performed his stunt as readily as a well-trained dog. Pluto, a splendid beast, posed at command upon a large fallen tree trunk. He turned and faced the opposite way when told to do so and gave the trainer a shampoo by licking the back of his neck and hair while he stood with his back to the lion. Finally the trainer sprang upon Pluto's back and rode him bareback around the lot without a bridle.

Several of these huge lions stood up on their hind legs and placed their front paws around their trainer's neck while they seized a piece of raw meat out of his upstretched hand. There they stood fully eight feet high, quietly towering over this man whom they could have crushed with one blow of their mighty paws.

Numa is the prince of this wonderful aggregation. He is a handsome Nubian lion with a heavy black mane and a smooth tawny body. He is the kindliest and most intelligent lion that the trainer has ever known in all his twenty years' experience with wild beasts. You have probably seen Numa in the great animal motion pictures. He will work with any actor or actress under his trainer's direction, and will obey even a child. He registers all the lion emotions, but so far has never shown the slightest inclination to molest any human being. He will also work with any other kind of trained animal. He is a real star, for he has earned fifty thousand dollars during the past five years.

The trainer called his wife to come into the pasture with him. She spread a shawl on the ground and then lay down flat on her back. At the trainer's command, "Guard the lady!" Numa snarled at the trainer, who threatened him with a long whip. As the man backed away the lion followed, growling. Finally Numa sprang right over the trainer's wife and landed with two feet on each side of her body. He then crouched down over her, pinning her body beneath his shaggy mane while he opened his huge mouth and threatened to bite the trainer. At the signal "O. K.," Numa stepped over the woman and walked up to his trainer without a snarl and rubbed against him, like a purring cat. I asked the trainer's wife if the lion ever made a misstep. She said he once pounced upon her stomach and nearly knocked the breath out of her. As he weighs fully five hundred pounds, she thought her end had come.

I wondered why the trainer carried a three-pronged fork when he entered the yard with his tamest lion. I found he did that with any lion if any other person was going to en-

ter with him. He said, "There is no such thing as a tame lion. He is only a trained lion, and you can never tell what may happen if anything goes wrong. I am always prepared to protect the life of my assistant."

He has one big lion called Cyclone, which he never uses in his exhibitions, although he is trained. This lion, even as a cub, showed a mean disposition; he was always ready to bite or claw, and never could be trusted. The trainer said, "A lion never forgets his bad habits and seldom learns any good ones. A lion is born good or bad, and it is the trainer's business to find the good lions and never trust the bad ones."

Some lionesses bear cubs that all turn out to have good dispositions. It is strange that Mary, the lioness mated to the vicious and untrustworthy Cyclone, always bears cubs that prove to be good lions.

The secret of this trainer's success is the kind, patient, and understanding treatment he always gives his animals. Cruel treatment may make a good lion bad. On the other hand, kind treatment will not always make a bad lion good; he may be good only because he is afraid to be bad.

Big Boy was a lion who became a bully early in life. He bossed all of his mates and was always picking quarrels; he had the rest of the young lions scared. Finally these lions got tired of this domineering bully, and as if by common consent the whole bunch jumped upon him one morning and beat him unmercifully. He has never dared to domineer since, and goes around like a dog with his tail between his legs. He is still a mass of scars, and slinks out of the way of any lion that happens to come in his direction. Evidently a lion bully is just as much of a coward as a hu-

man bully, and loses his courage very quickly when faced with a plucky opponent.

There were many other interesting things to see at this unique farm, and I hope many of you will some day have an opportunity to see these things for yourselves.

Questions

1. How are most of the lions in captivity raised?
2. Why do not all lionesses raise their own cubs?
3. What changes in color occur in the eyes of lions?
4. Why are lion cubs spotted?
5. How are lions fed?
6. What great change occurs each day in the behavior of the lions?
7. How do the lions drink?
8. What are some of the tricks these lions performed?
9. What are some of the secrets in training lions?

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